THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 6 SEPTEMBER, 1956 No. 5

THROUGH THE EYES OF THE EDITOR

Charles H. Jamieson describes his technique for making complete dentures. He takes cognizance of modern advances in prosthodontics. The procedure is sound and practical. If it is properly carried out, it will produce excellent dentures. It does involve some compromises in the interest of expediency, but these compromises are made with an understanding of the possible errors they may introduce. His emphasis of the need for "good judgment" in treating edentulous patients is particularly timely.

Alexander A. Fisher discusses allergic sensitization of the skin and oral mucosa to acrylic resin denture material. He reports that some persons are sensitive to the acrylic resin monomer, but that they are not sensitive to the *fully cured* acrylic resin polymer. He points out that pressure reactions are often mistakenly considered to be allergic reactions. The pressures that cause the reactions may be due to the shrinkage and warpage that occur during the curing process or they may be due to faulty occlusion. He suggests that tests with the monomer alone are sufficient to determine whether or not a patient is allergic to the material, and that tests with dentures strapped on the skin may be misleading.

Donald F. Kemnitzer discusses the effects of the denture base upon esthetics, and describes in detail a technique for producing a denture base with a lifelike appearance. The procedure is especially applicable to dentures with acrylic resin teeth which have no pins or diatoric holes. By his method, the placement of the colors can be quite accurate. He recommends that the special coloring be extended to include the entire denture. The detailed coloring of the palate seems unnecessary except for the relatively few patients who throw their heads back for a hearty laugh, or otherwise expose the palate. The parts of a denture base that are not exposed need not be colored in detail. To recommend a specially colored denture for a patient who does not expose any part of the denture base is a questionable procedure. To fail to use the special coloring for a patient who does expose the denture base is to fail to make available to the patient the best that dentistry can offer.

Harry Sicher points out the controversial elements of discussions of centric relation and of the hinge axis determination, and discusses them on the basis of their biologic significance. While he does not set out to make a decision, he does project an explanation that is worthy of study. He introduces the term "median occlusal position," and a definition for the centric occlusal position which is different from that which is most commonly used. While the term and the definition of centric may be usable when patients with natural teeth are considered, they are of little use when patients without *any* teeth are considered. At some point in the construction of dentures, centric relation must be determined. *Ideally,* this should be done *before* any teeth are arranged in the trial dentures. A median occlusal position could hardly be located without any teeth. Likewise, the definition would not apply if there were no teeth. His description of the neuromuscular reactions should clarify the changes that do occur when the teeth (and the proprioceptive impulses from the periodontal tissues) are lost. The prosthodontist needs a starting point, and the most posterior position of the mandible could be this starting point, because it is a terminal position in the posterior direction. All other mandibu-

lar positions can be related to it. In the construction of complete dentures, the *method* of locating this terminal or border position is less important than that it is located accurately. The hinge axis method can be used to locate centric position as it is generally understood. While it may be true that the patient may not close often in this terminal or hinge position, any closures made in this position will cause the denture bases to slide on their supporting tissues if provision is not made for the equilibrium of all factors at this position. The patient with some natural teeth in the mouth has a different "signal system" for making occlusal contacts than the edentulous patient.

Harry Shpuntoff and William Shpuntoff suggest the study of centric relation and physiologic rest position by electromyography. They describe a technique for the use of the electromyograph in making such a study and compare its effectiveness with that of other methods. This procedure certainly has interesting possibilities from an investigative standpoint, and should be of great value in research. While the cost of the necessary equipment would prohibit its general and routine use for making registrations, results obtained by this method could be used as a criterion for judging the relative accuracy of other methods.

Lloyd George Parry discusses the relationship between the procedures used in the construction of dentures, and the tissues and structures with which they must function. He points out the fact that patients with natural teeth can get by with disharmonies in occlusion while the same disharmonies will be disastrous for denture wearers. He believes that the use of a central bearing mechanism will interfere with the correct registration of centric relation because of the crowding of the tongue. There is merit in this observation, especially for patients with large tongues. The statement that the condylar guidance angle can be varied with different amounts of closing pressure is open to question. The morphology of the temporomandibular joint cannot be varied that easily. It is quite likely that the variations he has observed are due to the shifting of the denture or recording bases on the ridges. He does not recommend the use of a palatal relief. While relief of the hard median raphe may not be necessary in all instances, relief should always be provided for the blood and nerve supply at the incisive papilla. The median raphe is hard enough, in many instances, that the denture will "rock" if relief is not provided. His suggestions for patient education are good, and his conclusion that techniques should be varied to accommodate the dentures to the supporting tissues is sound.

Balint Orban discusses the biologic principles involved in the correction of occlusal disharmonies. He explains the changes in bone that occur as the result of pressures, and shows how teeth may migrate in bone to adapt to the forces applied to them. He points out the fact that this adaptability varies with both intrinsic and extrinsic factors, and concludes that optimal harmonious relationships between all factors should be developed to eliminate the conditions which lead to a breakdown of the supporting tissues.

Homer Cree Vaughan discusses some important factors in the occlusion of complete dentures. He describes a method for locating the dental arch in relation to the musculature. This could be significant because of the loss of proprioceptive impulses from the periodontal tissues and the consequent adaptive changes in the operation of the neuromuscular system when dentures are worn. While the principle seems sound, there may be some question about the method. Further study is indicated. Certainly, the contour of the mandibular ridge should not be ignored in locating the distal end of the occluding surfaces. A tooth placed on a markedly inclined plane (anteroposterior) will be a disturbing factor to the stability of a lower denture. He disagrees with other authors regarding the action of the posterior fibers of the temporalis muscle. He states that these fibers do not retract the coronoid process of the mandible. While it is possible that he has not observed this action, it does not mean that it *could not* occur under the proper stimulation. The orientation of these fibers is such that they *could* tend to retract the coronoid process, but under other conditions their action could be entirely different. The complex arrangement of the musculature of the mandible makes almost any action or movement possible, provided the conditions are right.

Roy C. Hill describes his treatment of an acromegalic patient. While patients suffering from acromegalia have widely varied dental problems and the treatment must be varied accordingly, the method used for treating this patient can be used as a starting point.

Ralph W. Phillips and Leo J. Leonard report on their studies of enamel abrasion by partial denture clasps. This is a very timely investigation because of the many opinions that are expressed about the abrasive effects of different alloys. These opinions have been given with theoretical or clinical bases. The test methods used were cleverly worked out and appear to indicate a true evaluation of the abrasive effects of clasps. They found no significant difference in the abrasive effect of different alloys under test conditions. They suggest the need for the study of other factors which do cause the abrasion of enamel which is apparent clinically in some instances.

Anthony K. Kaires reports his studies of partial denture design as it relates to force distribution and masticatory performance. The experiments were made upon a partial denture of complex design and continued with the same denture being modified to one of simple design. Strain gauges were used to test the force distribution with each design. Interchangeable occlusal tables were used to test the force distribution and masticatory efficiency with different occlusal forms. He warns that his conclusions are based upon observations made on only one patient. They are thus subject to limitations. His conclusions seem to be in line with clinical observations.

Carlisle C. Bastian discusses the restoration of lower anterior teeth, and describes the different types of restorations that can be used for this purpose. He gives the indications, advantages, and disadvantages of each type of restoration, and favors the porcelain jacket crown where it can be used.

Nathaniel Goldrich and Samuel Schneider describe a direct technique for making acrylic resin veneer crowns. The procedure is simple and should be effective if it is carried out properly.

Milton Silver, George Klein, and Michael C. Howard discuss restorations made of porcelain baked on platinum castings, and describe a technique for making these restorations. They point out the merits of these materials for fixed restorations and compare them with other available materials. The porcelain used has a higher fusing point than that used when the porcelain is to be fused to gold. This should produce a better color and texture of the porcelain parts. The difficulties appear to be in the proper formation of the platinum castings. It will be interesting to compare the clinical results over a period of time with restorations which are made of porcelain baked on gold.

Abraham Lamstein and Harry Blechman report their investigation of marginal seepage around acrylic resin veneers in gold crowns. The results indicate that there is a leakage at the margins of acrylic resin veneers. This was accelerated by the test methods used. The permeability of the veneers themselves was shown to be negligible. Their conclusion that gold crowns should not be perforated under acrylic resin veneers seems to be supported by the results of their tests.

E. D. Shooshan discusses the role of the general practitioner of dentistry in the maintenance of oral health. He emphasizes the need for a well-rounded training and experience for making the right diagnosis and best treatment plan for a patient. He suggests certain techniques which should be used in making a diagnosis. The increasing tendency toward specialization seems to indicate that his suggestions are correct. The limitation of a practice to a narrow field does not relieve the specialist from a broad responsibility.

William L. Kydd reports his studies of the horizontal forces of occlusion developed by different occlusal forms. He measured the deformation of the denture base that occurred when the test dentures were in function. The results indicate that cusp teeth cause greater horizontal deformation of the denture base than cuspless teeth when in function, and it is implied from this that cusp teeth produce more lateral thrust than cuspless teeth. The results are not conclusive because the study was carried out with only one patient, and the method of changing the tooth forms might cause a difference in the results. This type of study deserves further investigation.

—Carl O. Boucher

A MODERN CONCEPT OF COMPLETE DENTURES

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MODERN RESEARCH IN THE anatomic, biologic, and physical sciences has contributed so greatly to the advancement of dentistry that the complete dentures delivered today are as unlike those of 1925 as the high-styled multihued Ford of 1955 is to its ancestors.

The patients who come to us for service are better informed on dental health through the press, the radio, and the television, and they expect more comfort, more efficiency, and better esthetics than their parents had. I believe they are getting it in the modern dental office.

CONSULTATION

It is quite usual that a description of the sequence of denture construction begins with the examination of the mouth, but the advances made in the study of psychosomatics in recent years emphasize the value and importance of a more intensive search into the history of the patient's previous dental experiences before picking up the mouth mirror.

Ryan[1] writes, "To establish satisfactory dentist-patient relationship, the dentist needs to know what may happen to the body of man when his mind is disturbed, and what may happen to the mind and behavior of man when his body is diseased. What one experiences, the other expresses, wounds of the spirit are expressed in malfunctioning of the body. Injury and disease of the body produces changes in feeling, tone, and emotional responses. The one word psychosomatic defines organismal unity and totality—no treatment can be either psychic or somatic. Every treatment is both.

"The anxieties of people who come for dental treatment are shown in their gait, their posture, their face, their voice . . . . We have learned to look with a magnifying lens at the hard and soft tissues of the mouth. We interpret the meaning of the shadows in x-rays. Bacteriologic and biochemical tests have been developed that will aid us in diagnosing. But let us never forget to look at and to listen to the person who is the patient . . . . The voice affords us another important clue in diagnosis. The patient reveals feelings and values in his voice. We must remember that the relationship is reciprocal; the dentist also reveals his feelings, his attitudes, and values to the patient. While we are making a diagnosis the patient is also making an evaluation. The voice is a two-way diagnostic circuit."

Read before the Ohio State Dental Association, Cleveland, Ohio, Nov. 13, 1955.
Received for publication Dec. 17, 1955.

An informal consultation interspersed with leading questions related to these experiences will reveal the patient's attitude toward life in general, and dentistry in particular. Is he critical and skeptical, apprehensive or confident, sensitive or tolerant, happy or discontented? What is expected of new dentures? If oral surgery is anticipated, what has been the experience with previous episodes? If edentulous, for how long; if he is now wearing dentures, with what satisfaction? Such questioning will reveal directly or indirectly the patient's reaction to the successful or unsuccessful attempts of other dentists to treat the dental condition. This is not done to provide an opening for the questioner to criticize the other dentist, but rather to catalogue mentally those characteristics of the patient which will influence his future treatment. The patient who has been displeased with eight sets of dentures may present the same anatomic problems as the patient who has been satisfied with one. The treatment plan for the former must be more exact in detail from both physical and psychologic aspects to attain success. The consultation is the important preliminary step.

EXAMINATION

A detailed examination of the oral cavity and adjacent structures with the mouth mirror, roentgenograms, and palpation are the next aids in the treatment plan, to determine the areas favorable for the support of the denture that these may be fully utilized, as well as the areas unfavorable that they may be minimized.

One of the fundamentals still too often overlooked in denture planning is adequate coverage for support, retention, and stability. This means that for maximum efficiency the denture should reproduce the structures lost through extraction and subsequent resorption to maintain the normal relation between all oral tissues. This does not mean that, in badly mutilated mouths, the mechanics of function can be ignored, but rather that a compromise must be attained by altering normal contours as little as possible. In other words, the more nearly one can approach the reproduction of lost form and structure, the more normal will be the function of all of the related parts of the oral mechanism.

It is recognized that the changes in physical form of the supporting ridges through resorption alter their relation to the border tissue attachments. The greater the resorption, the less the border extension. In direct proportion, also, is the limitation of movement of the peripheral tissues to reduce dislodgment of the denture. For example, with excessive resorption of the lower posterior ridges, the protrusive movement of the tongue may be limited to a mere contact of the tip to the borders of the lips to permit the lingual denture border to be carried as low as possible. Similarly, the buccal border can be carried to the external oblique ridge if it is well rounded, and the buccinator and masseter muscles are somewhat limited in their movements.

The tongue merits further study. Its color is an indicator of the patient's physical condition. Its size may be a hindrance in the early experiences of learning to use dentures. Its position at rest may assist or interfere with the retention of the lower denture.

Wright[2] has discussed the influence of tongue position on the lower denture, and pointed out the advantage of the forward position of the tongue to seal the lingual border in function. The patient who learns to place his tongue in this position involuntarily is aided greatly in maintaining the stability and retention of his dentures.

PRE-EXTRACTION RECORDS

The oral examination cannot be considered complete without study casts being made for a deliberate analysis of the ridge contour and border attachments. The alginate impression materials have made this operation quick and easy. Study casts are of great value in treatment planning for both dentulous and edentulous patients.

If extractions or oral surgery are considered, and immediate dentures are contraindicated, pre-extraction facial measurements are made with the Sorenson dentofacial gauge, and recorded for use when the dentures are being constructed.

IMPRESSIONS

Modern impression techniques are numerous, but may be generally classified as to jaw position and the degree of pressure, nonpressure, negative pressure or selective pressure. Presently the open mouth technique has the greater number of advocates, and the nonpressure or selective pressure techniques are widely used. There can be no universal impression technique which can be applied to all patients, but there can be a basic technique for what is termed an average patient. This technique should be capable of revision depending upon the anatomic variations which examination of the mouth reveals.[3]

On a cast made from a preliminary impression of each individual patient, a rigid durable tray can be made in a few minutes with an autopolymerizing plastic, or from a thermoplastic material which is easily adapted with a Bunsen flame. My preference is for the close-fitting tray which permits uniform guided seating with each insertion during impression making. This close-fitting tray can be tried in the mouth, and the borders can be trimmed to permit freedom of all muscle movements. The borders can be adapted accurately with stick modeling compound to conform to the functional movements of the border structures to perfect a seal without displacement of these structures. The impression is completed with an easy-flowing zinc oxide and eugenol paste to register the fine detail in the contours of the supporting structures.

This technique provides a control of the tissues in both the hard and the soft areas. Hard areas or knife-edge ridges are relieved by scraping the preliminary impression before the plaster cast, for making the tray, is poured. Soft, resilient, or flabby areas or knife-edge ridges are reproduced in their normal position without distortional pressure. The aim of this selective pressure technique is to produce an impression which permits equal distribution of masticatory stress upon all of the supporting tissue.

BASEPLATES AND OCCLUSION RIMS

Since accuracy in technique is the best assurance of a successful product, the adaptation of baseplates and occlusion rims to the casts is an important step. A

rigid, nonwarping baseplate is a necessity if an accurate registration of centric relation is to be secured. The need for frequent removal of the baseplates from the casts during the working period increases the opportunity for distortion, particularly if undercuts exist on the casts. The baseplates should not be carried into these undercuts if distortion is to be avoided, but they should be carefully adapted to the casts to permit their easy removal. They should be further stabilized with a zinc oxide and eugenol paste or autopolymerizing acrylic resin. When placed in the mouth, the baseplates should seat and be retained without rocking. The paste lining is somewhat adhesive and assists in retention.

In adapting occlusion rims preparatory to the registration of centric relation, basic average outlines may be suggested. The average distance between the upper and lower labial sulci adjacent to the labial frenula when teeth are in occlusion is considered to be 40 mm. The distance from the upper sulcus to the incisal edge of the upper central incisor is an average of 22 mm., and the distance from the lower sulcus to the incisal edge of the lower central incisor is an average of 18 mm., totaling 40 mm. The occlusal plane of the lower molars is usually level with the retromolar pad. Thus, the lower occlusion rim can be built to this height, and preferably to a curve approximating a segment of a sphere. The occlusion rim should be built labially and buccally to reproduce, as nearly as possible, the contour which the natural teeth presented. This is a matter of judgment involving an estimate of the amount of resorption of the ridge that has occurred.

The upper occlusion rim is built 22 mm. high from the labial sulcus on the cast. In the second molar region, it is built to an average of 8 mm. above the crest of the ridge. The occluding surface is made to conform to the reverse of the curve of the lower occlusion rim.

When placed in the mouth, occlusion rims thus contoured usually have adequate height, and if the height is excessive, it can be reduced easily to the selected vertical dimension. The labial and buccal surfaces of the occlusion rims are shaped to reproduce the contours of the teeth and tissues before extraction and resorption. The lingual surfaces of the occlusion rims are contoured to conform to the lingual margins of the ridges.

VERTICAL DIMENSION AND CENTRIC RELATION

Modern denture techniques have emphasized the importance of the establishment of correct vertical dimension and centric relation as being essential to the restoration of normal masticatory function. The determination of the proper vertical relation between the maxillae and mandible may be achieved by several methods. It is important to secure an accurate measurement of the degree of jaw separation when the mandible is in rest position, or that position assumed by the mandible when all muscles associated with masticatory function are in a state of balanced tonicity. The problem is to find that position and record it consistently, and much research has been devoted to this phase of denture technique.

In the rest position, the teeth are not in occlusion, and the space between the upper and lower incisors may vary from 2 to 10 mm. or more. This interocclusal distance (free-way space) varies in a degree proportionate with age and natural abrasion of teeth through occlusal wear. To record this position, the patient must be completely relaxed. If relaxation is difficult to obtain, a sedative, in the form of a barbiturate, may be administered.

A simple technique for measuring the vertical dimension of rest position is to make dots with a pencil or to place small triangles of adhesive tape on the tip of the nose and on the tip of the chin where the tissue is firm. These serve as reference points for measurements. The patient must be seated upright in the chair in a normal sitting position. He is directed to moisten his lips with his tongue, to swallow, and then to relax at the completion of the swallowing act. The distance between the dots is measured with a millimeter scale or dividers at this time. This procedure is repeated several times to determine the measurement, which is duplicated time after time. It is sometimes necessary to have the patient swallow a little water to moisten the mouth if it becomes too dry from repeated attempts to swallow. It is well also to separate the lips to note the approximate space existing between the teeth or ridges at the end of the swallowing cycle. The patient may be asked to hold the mouth wide open for a time which will tend to tire the muscles, and thereby assist him to assume a relaxed position of the mandible more easily. It may be necessary to instruct some patients and have them practice relaxation at home before the next appointment. Unless the rest position measurement is the same when it is repeated, it should not be accepted for guidance in determining centric relation and vertical dimension.

It has been stated that the rest position is constant throughout life, but it seems that practical clinical experience refutes this contention. Mandibular position is dependent upon a three-dimensional equilibrium of its associated musculature. With the normal change in muscle tonus as age progresses, there is a relaxation or a "sagging" of facial muscles, and it seems logical to assume that the muscles which control the position of the mandible would also undergo a physiologic change in function and structure, altering the relation of the mandible to the maxillae in rest position. When complete dentures are being made for a patient 65 years of age, we have no way of knowing what his physiologic rest position was at the age of 20. The position is recorded as we find it, and when checked and rechecked, it is accepted as accurate. Often a compromise must be accomplished, and a centric relation established in harmony with existing factors.

If we accept the contention that youth maintains an interocclusal distance of 1.5 or 2 mm. and that aging increases this distance by attrition, a centric relation can be accepted which will decrease the vertical dimension 2 to 4 mm. from the recorded rest position, and thus permit freedom in speech. If there is need to decrease the muscular stresses upon the ridges to reduce trauma, the vertical dimension should be decreased proportionately.

REGISTRATION OF CENTRIC RELATION

The lower occlusion rim is first tried in the mouth, and the anterior part is trimmed to the height of the lower lip at rest, and tapered back to the retromolar

pad, which is the indicator of the height of the occlusal plane in the molar region. The upper occlusion rim is now tried in and trimmed to occlusal contact with the lower occlusion rim at the recorded vertical dimension, as measured with the dividers. The wax rims are in equal contact all around. The median line is marked on both upper and lower occlusion rims, and a vertical mark is made in them in the first molar region on each side. A "V-shaped" notch is cut in the wax at this location. The rims are tried in the mouth several times, and, with the patient sitting erect, he is told to close, until they contact, and to swallow. Then the vertical lines are checked to see if they coincide routinely. If they do, the patient is relaxed and no difficulty is expected in securing the centric relation record.

If the lines do not coincide at each trial, patient training is necessary. With instruction to curl up the tip of the tongue in the palate, the mandible is retruded. It may be necessary to change the markings of the vertical lines on the occlusion rims while the patient is practicing this movement until he can easily repeat closures in the correct position. It is possible to get a strained retrusion if extreme effort is made by the patient, but if he is told to close easily with the tongue back, normal centric relation can be registered repeatedly.

THE FACE-BOW

The face-bow is recognized as an important aid in the orientation of casts on an articulator in a position approximating that of the maxillae and mandible to the temporomandibular joint. The degree of approximation is dependent upon the accuracy of transfer technique.

Several hinge-axis face-bows have been devised for locating the rotation centers of the condyles. When used correctly, this technique is of proved value. In practical application, however, the arbitrary technique of transfer as advocated by Hanau with face-bow model "C" is acceptable. The location of the axial center of the condyle is determined by an average measurement of one-half inch anterior to the center of the tragus of the ear, in line with the corner of the eye. A pencil dot is made at this point, and it is used to locate the condyle rod of the face-bow on the face.

The fork of the face-bow is attached to the upper occlusion rim, the condyle rods are centered over the dots with equal calibrations on each side, and the adjustment screws are set. I prefer to mount the upper cast prior to registering centric relation, but both procedures can be done at the same time if desired.

A small ball of very soft beeswax, or a wax of similar consistency, is placed in the notches in the wax rims on each side, and the patient is told to close lightly, as before, until the occlusion rims are within 1 mm. of contact. This uniformly softened wax seats the baseplates on the ridges with equalized light pressure and avoids a distortion which might occur if the hard wax rims were to touch. The rims are fastened together with staples or with a warm spatula and are removed from the mouth without distortion.

This method of registering centric relation is one of several which can record the maxillomandibular relation accurately. Through the years I have tried

all techniques, including those which employ various types of central bearing points and needle point tracers, but for simplification and uniform results the method described is preferred.

TOOTH SELECTION AND POSITIONING

In the selection of anterior teeth, pleasing esthetics is the first consideration. Esthetics is influenced by the size and shape of the anterior teeth, their color, and arrangement. Selection should not be made until the vertical relation of the jaws has been determined with the occlusion rims, and facial contours are more nearly normal.

Frush and Fisher[4] have suggested that the sex, personality, and age of the pa-ient be considered as fundamental factors in the selection of teeth. The sex and personality of the patient combine to determine the boldness or the mildness of the esthetic treatment. The size and shape of the anterior teeth must harmonize with the lips which frame the teeth in smiling and speaking, and the picture must be proportionate to the frame. The sex of the patient is not the determining factor in size selection, but it is more likely to influence the shape and position of the teeth. The male patient usually requires the more severe arrangement. The age of the patient is important in color selection and tooth positioning. As years pass, attrition, injury, and repair affect the color of teeth individually, and with relation to each other in arrangement. Skin textures change with the years also, and harmony of teeth and their supporting tissues produces pleasing esthetics. The reshaping of teeth and the blending of harmonious shades do much to disguise the artificiality of tooth positioning.

The use of immediate denture service, with its many esthetic and psychologic advantages, has focused attention on the accurate reproduction of natural tooth position in complete dentures. This method of arrangement has been urged by Pound.[5] His four principles for the "natural" arrangement of teeth may be restated as follows:

1. The occlusal plane should be parallel with the floor when the patient is standing or sitting erect.
2. There should be a clearance of 1 or 2 mm. between the upper and lower anterior teeth when the "S" sound is produced.
3. The correct amount of tongue space should be provided by placing the lingual surfaces of the lower posterior teeth in line with the lingual border of the retromolar pad.
4. The natural position of the tooth with relation to the ridge should be duplicated.

Pound[5] states that phonetics is controlled by that phase of esthetics that is affected by tooth position. He believes that the mechanical factors of tooth placement, wherein the teeth are placed over the center of the residual ridge, have been overemphasized at the expense of esthetics and phonetics, and that patients' faces can retain their natural characteristics only when all oral structures are in their normal relation to each other in function. Palatal contours should be reproduced,

since an improperly developed tongue space is the cause of many phonetic errors. The development of a fullness of the denture base contour lingual to the upper molar teeth is often an aid in eliminating the whistling sounds caused by the escape of air along the lateral borders of the tongue when sibilants are used in speech. Pound's reasoning is logical and his principles can be followed except when extreme anatomic variations demand a compromise.

POSTERIOR TEETH

Posterior tooth forms have received a great deal of attention since Sears introduced the first nonanatomic teeth which he designated as "chewing members" in 1922. He stated[6] that the horizontal forces which the anatomic occlusal forms directed upon the ridges were more detrimental than the vertical forces which nonanatomic occlusal forms directed upon the ridges.

The decision to use plastic or porcelain teeth in either anatomic or nonanatomic forms is determined mainly by the anatomic factors that may be present.

The selection of the posterior tooth form to be used is dependent upon the relationship between the maxillary and mandibular ridges in both horizontal and vertical positions, the ridge shape, whether flat, knife-edged, or normally rounded, and the anticipated forces to be exerted by the muscles of mastication.

A cusp tooth should be used when: (1) the factors listed above are considered normal or near normal; (2) esthetics demands a deep vertical overlap; (3) the muscle tonus is average.

A cuspless tooth should be used when: (1) the ridge form is flat or knife-edged; (2) the ridge relation is abnormal and cuspal interdigitation is not possible; (3) muscle tonus is weak.

The maximum in masticating efficiency and comfort can be achieved only by the proper evaluation of these diagnostic factors.

My preference is for the porcelain, modified anatomic tooth for the so-called "normal" patient. By normal is meant one with well-shaped ridges that are proportionate in size and relation to each other, and with healthy mucosa of uniform thickness. I believe that the maximum in masticating efficiency and comfort will be attained with these teeth.

Usually, the lower ridge must be favored when positioning the teeth and be given every advantage in leverage and mechanics. Therefore, it seems logical to set the lower teeth first, approximating the natural tooth position as closely as the anatomic variations of the ridge will permit. Teeth set at right angles to the ridge will result in greater stability. Ridges that are short anteroposteriorly frequently require the omission of a bicuspid or a second molar, especially if excessive resorption has produced a ridge that rises abruptly in the second molar area.

The upper teeth are set in occlusion with the lower teeth and balanced in all ranges of movement. Continued stability of denture bases cannot be maintained without balanced occlusion. In the act of swallowing, balanced occlusion is necessary, and swallowing occurs involuntarily about every 60 to 75 seconds. This seats the dentures uniformly upon the supporting structures if the occlusion

is balanced. To maintain a posterior palatal seal, balanced occlusion is also necessary in protrusive positions. While this may alter the desired esthetics of patients with a deep vertical overlap, a satisfactory compromise can usually be achieved.

TRY-IN

Several observations should be made at the try-in stage. With the patient relaxed and in a normal upright sitting position, the trial dentures are inserted and the patient is told to close lightly and swallow. With the previous training for making the centric relation registration, centric position should be assumed readily. The patient taps the teeth together lightly in this position and is asked if both sides touch at the same time or if any one spot strikes harder than another. The reply dictates the next step. If one side is in premature contact, a new centric relation registration is made with a thin strip of soft wax on the posterior teeth, the lower cast is remounted on the articulator, and the malposed teeth are reset for another trial.

The occlusal vertical dimension is checked while the patient is directed to repeat the alphabet several times, each time a little faster. Then he is asked if the back teeth touched during this test. If this is done with a little humorous twist, the patient is more relaxed, and will even venture a smile or a laugh which will display the anterior teeth and the smiling line of the lip. If the posterior teeth do touch in this test, the occlusal vertical dimension should be decreased. It is assumed that the trial dentures are stable during the test.

A protrusive wax maxillomandibular record is made in the mouth, and the condylar adjustments are made on the articulator. The posterior teeth are reset, if necessary, to balance the occlusion.

When the dentist is satisfied with the arrangement of the teeth, the patient is permitted to view the teeth, and his comments and suggestions are invited. If the suggested changes are logical, they are made willingly, but if they are illogical, they must be dismissed tactfully. The patient's acceptance of the arrangement of the teeth and esthetics is vital to success, and it is unwise to proceed in the construction of the dentures without it.

Various methods of staining, tinting, and color impregnation are being used to improve the esthetics of synthetic resins, and we can truly say that the visible base material on a denture in function is no longer displeasing.

REMOUNTING FOR EQUILIBRATION OF OCCLUSION

The dentures are remounted on the articulator after processing. They are deflasked carefully, and left on the casts with their keyed bases, and thus can be put on the articulator in the original mountings. By this procedure, any discrepancies in occlusion which may have occurred during processing may be checked. Centric occlusion is checked with blue articulating paper, and the protrusive and lateral occlusions with the original condylar inclinations are checked with red articulating paper. A cusp that is marked with both blue and red is adjudged to be correct, and the opposing sulcus is ground sufficiently with a small stone to achieve balance. The contacts made by each tooth are checked in various

positions, and they are carefully ground to produce a balanced occlusion with the functional range of movement. The upper and lower anterior teeth should make contact in protrusive and lateral positions only, with the posterior teeth maintaining balancing contacts in centric occlusion as well as in protrusive and lateral occlusions. Milling with abrasive paste is done lightly only to perfect the balance after the major equilibrating has been done with the small stones in a handpiece. Indiscriminate milling will reduce the height of cusps excessively, and tend to reduce the occlusal vertical dimension and destroy the balance in lateral occlusion. Occlusal adjustments made in the mouth should be limited to the elimination of minor discrepancies. Instability of the bases on varying hard and soft tissues of the ridges make major occlusal adjustments in the mouth hazardous.

After the dentures are ground-in on the articulator, the final polishing is done in the laboratory with insistence that the borders be finished exactly as indicated in the impressions. If the waxing and contouring have been done carefully, little polishing is required.

DELIVERY OF THE DENTURES

The dentures are placed in position with the patient sitting upright, and then he is instructed to close firmly and to swallow. Patients tend to swallow lazily, and as a result the salivary glands are not stimulated to function normally. Instructions to swallow vigorously and frequently during the learning period with dentures induce a good habit which assists in the adaptation of the denture bases. If the dentures tend to loosen, a closure into centric occlusion and swallowing seats them accurately. The patient is given a denture brush and instructed as to its use. He is provided with a booklet of instructions, *A Few Tips From Your Dentist* prepared by the Detroit Dental Clinic Club. Sears' book,[8] *New Teeth for Old,* is also an excellent source of information for the denture wearer, whether he is a beginner or a veteran.

If possible, the patient returns the following day, having worn the dentures continually except for the cleansing period. At this time minor border and occlusal adjustments can be made, if necessary. Major irritations should not exist if care has been used in all steps of the construction.

A review of the instructions and a reassurance for the patient who is wearing dentures for the first time will be helpful. An appraisal of the patient's reaction to his denture problem determines the future treatment. A definite appointment is made for further adjustments or the patient is told to telephone for an appointment whenever help is needed. Since adjustments are as important as any step in construction, the patient is impressed with this fact and with our continued interest in his welfare. If he does not return in a week or two, inquiry is made by telephone as to his progress and an appointment is made, if necessary. The willingness to adjust and treat the troublesome case is a prime requisite for final success, and the best deterrent to the unhappy patient we tend to call neurotic.

How long shall we treat the troublesome case? Patients should be treated until, in our own minds, we can honestly say, "I see nothing from an anatomic, mechanical, physiologic, or psychologic review of this case that I can improve." Our obligation is not fulfilled until this point is reached.

As in any worth-while endeavor, prosthodontics demands the exercise of good judgment. Good judgment comes from experience, and experience comes from poor judgment. The errors of the past are the safeguards of the future.

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ALLERGIC SENSITIZATION OF THE SKIN AND ORAL MUCOSA TO ACRYLIC RESIN DENTURE MATERIALS*

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DENTISTS HANDLING ACRYLIC RESIN materials and fitting acrylic resin dentures are concerned with the sensitizing and irritating properties of these materials. Often the physician, especially the dermatologist or allergist, is appealed to for aid in determining the relationship of certain symptoms and signs appearing on the skin or oral mucosa which have come in contact with acrylic resin materials.

This study was initiated because many individuals who had oral symptoms coincidental with the wearing of acrylic resin dentures were often erroneously labeled as being "allergic" to acrylic resin dentures when, in reality, there were other causes for the "denture sore mouth."

Statistics from several large dental laboratories in New York City and vicinity show that over 90 per cent of the dentures made today are processed from acrylic resins. In addition to the heat-cured resins used in making entire dentures, a great deal of acrylic resin denture relining and repair material is used that is self-curing without the application of heat.

The acrylic resin denture base materials[1] with which I am concerned are marketed in two forms: a powder polymer and liquid monomer that are designed to be mixed to a dough by the dental laboratory technician or dentist, and a gel, in which the polymer and monomer are already mixed by the manufacturer. The liquid monomer is methyl methacrylate, and the powder is polymethyl methacrylate. When the mixed liquid and powder or gel is heated, further polymerization takes place, and the mixture hardens to form the familiar pink denture base material.

In addition to these denture materials that require heat for polymerization, similar materials that will polymerize at room temperature are used for repairing and relining dentures.[2] These self-curing resins are created by inducing polymerization of a mixture of methyl methacrylate monomer and polymethyl methacrylate powder with an organic peroxide and an accelerator or promoter. The most commonly used accelerator at present is the tertiary amine, dimethyl-p-toluidine.[3] The self-cured resins do not have the same mechanical properties as those resins polymerized at high temperatures, and they normally contain a somewhat higher residual monomer content than the heat-cured resins.

Reports in the literature[4-13] vary greatly as to the primary irritating and sensitizing potential of these materials on dental laboratory technicians and dentists.

*From an article, with certain modifications, which appeared in the Journal of the American Medical Association, 156:238-242 (Sept. 18), 1954.

Received for publication Dec. 30, 1955.

Even more controversial are the reported incidents of irritation and allergic sensitization of the oral mucosa in those who wear acrylic resin dentures.

A review of the available reports shows that the reactions may be divided into the following categories: (1) allergic, eczematous, contact type of dermatitis affecting dentists and dental laboratory technicians, and (2) allergic stomatitis (sore mouth due to dentures) affecting wearers of dentures. The cases I have studied also fall into these categories. Each will be described separately, since they present different problems.

CONTACT TYPE OF DERMATITIS

We have encountered contact type of dermatitis due to acrylic resin materials in several dentists and dental laboratory technicians. Stevenson[4] and Moody[5] have reported allergic, eczematous, contact dermatitis of the hands and face of dentists; this dermatitis was caused by the acrylic resin monomer. Stoy[6] cited several dental laboratory technicians with local dermatitis caused by this monomer. Hollander and Kennedy[7] reported the case of a dentist with a dermatitis of the hands in which they obtained a strongly positive patch test with the self-curing dental material. It is not clear whether or not they tested the polymer and monomer separately. I studied four patients with severe dermatitis of the hands that I proved by patch tests to be caused by allergic sensitivity to the liquid monomer. These patients' conditions cleared promptly when the monomer was avoided, and relapsed promptly on re-exposure to the agent. The pertinent clinical data of these cases follow.

Case 1.—A dentist, aged 50 years, had a dermatitis of the right hand for eight months that was characterized by vesiculation, redness, and fissuring which was most marked on the thumb and forefinger. After it was proved by patch testing that his dermatitis was due to acrylic resin monomer, he avoided this substance and the dermatitis promptly subsided.

Case 2.—A dentist, aged 45 years, had a chronic dermatitis of the right hand of one year's duration that was most marked on the first three fingers, and characterized by marked dryness and fissuring. Occasionally there were exacerbations of the dermatitis with vesiculation. All patch tests were negative except that with acrylic resin monomer. When the patient avoids contact with the monomer, the dermatitis promptly subsides. When there is inadvertent contact with the monomer, the eruption promptly recurs.

Case 3.—A dental laboratory technician, aged 55 years, had severe dermatitis of both hands for eight months. The dermatitis was characterized by redness, swelling, vesiculation, scaling, dryness, and fissuring. His condition would improve over week-ends and on vacations. This patient had to discontinue his work as a dental laboratory technician because of his sensitivity to the liquid monomer. His hands have remained clear after he stopped working with the monomer. It is notable that this patient wears an acrylic resin denture without difficulty.

Case 4.—A dental laboratory technician, aged 46 years, had a dermatitis of both hands for four months. The clinical picture was similar to that of the patient reported on in Case 3. He is able to wear an acrylic resin denture without any difficulty. When the patient avoids contact with liquid monomer, his hands promptly clear, and the eruption just as promptly recurs when he comes in contact with the monomer again.

After it was proved, by patch testing procedures and by observation of clinical responses to avoidance and re-exposure, that these patients had allergic eczematous dermatitis due to sensitization to methyl methacrylate (liquid monomer), they

were tested for sensitivity to the following materials: (1) the monomer used in the heat-cured denture material, (2) the self-curing monomer, (3) the polymer powder, (4) a nickel-sized disk made with the self-curing monomer and polymer, (5) a similar disk made with the heat-cured monomer and polymer, (6) a Luxene bar, which is made with vinyl acetate and vinyl chloride plasticized with a small amount of methyl methacrylate monomer, and (7) an entire denture strapped onto the forearm and left there for forty-eight hours.

Table I shows that all the patients reacted strongly to the self-curing and regular monomers. They also reacted to the disk made with the self-curing material. They did not react to the polymer, the disk made with the heated material, or to the Luxene bar.

The only reactions obtained were with the self-curing and regular monomers. Patch tests with the polymer, that is, polymethyl methacrylate, were negative. With the heat-cured disk, polymerization was apparently complete, and there was no residual monomer left to give a reaction. With the self-cured disk, on the other hand, there was sufficient monomer left unpolymerized to produce a definite eczematous reaction on patch testing. The Luxene bar, which is a vinyl plastic in which acrylic resin monomer is used as a plasticizer, likewise showed no reaction, indicating that here also the acrylic resin monomer was completely polymerized. The redness and slight swelling that I found on the removal of the entire denture, I interpreted to be due to simple pressure effects. It should be noted also that the patient reported on in Case 3 was able to wear an upper and lower acrylic resin denture without any symptoms, and that the patient in Case 4 could tolerate a partial denture of acrylic resin material. This tends to show that persons who are very sensitive to the liquid acrylic resin monomer nevertheless tolerate heat-cured acrylic resin dentures in which the liquid monomer has been completely polymerized.

TABLE I. RESULTS OF PATCH TESTING OF PATIENTS WITH ALLERGIC SENSITIVITY TO ACRYLI RESIN MONOMER

	CASE 1	CASE 2	CASE 3	CASE 4
Self-curing monomer	3+	3+	3+	3+
Regular monomer	3+	3+	3+	3+
Polymer powder	Neg.	Neg.	Neg.	Neg.
Heat-cured disk	Neg.	Neg.	Neg.	Neg.
Self-cured disk	2+	2+	2+	2+
Luxene bar	Neg.	Neg.	Neg.	Neg.
Heat-cured acrylic resin denture	N.	N.	N.	N.

3+ = Erythema, edema, and vesiculation.
2+ = Erythema and edema.
Neg. = No reaction.
N. = Nonspecific pressure effects: redness and swelling at maximum points of pressure.

SORE MOUTH DUE TO DENTURES

The term "sore mouth due to dentures"[8] is applied to any pathologic change of the oral mucosa due to dentures, whether the cause is allergic, traumatic, or

toxic. If the cause is allergic, the term "stomatitis venenata" is used by some authors. The patient may complain of a burning sensation, soreness, dryness, or excessive salivation. Examination of the oral mucosa may show punctate or diffuse redness with or without erosions. At times the mucosa looks normal, yet the patient complains of a sore mouth when wearing the denture. On the other hand, a routine examination may show a deep red imprint of the denture, but the wearer has no complaints.

I studied 20 patients who wore acrylic resin dentures and had sore mouths due to dentures. Their symptoms had been present for three months to two years. All of these patients were women. I have been unable to explain the reason for the absence of male patients in this series. Four of these patients had been informed, either in our clinic or elsewhere, that they were allergic to their acrylic resin dentures and had been advised to change to another type of denture.

The diagnosis, in large part, had been based on an alleged positive patch test obtained after the denture had been strapped to the forearm for forty-eight hours. I was fortunate to be able to contact the four patients, retest them, and reappraise the diagnosis of allergy to their acrylic resin dentures. The case histories of the four patients labeled as being allergic to their acrylic resin dentures are presented briefly below.

CASE 5.—A woman, aged 70 years, had had burning and soreness in the mouth soon after acquiring a complete set of acrylic resin dentures. Examination had showed a diffuse redness of the hard palate with a few scattered punctate erosions. A patch test performed by strapping the entire denture to the patient's forearm for forty-eight hours had resulted in a fine vesicular eruption under the denture. The patient had been informed that she was allergic to acrylic resin dentures, and she had been advised to change to vulcanite dentures. Wearing a vulcanite denture had not ameliorated her symptoms. Finally, on the advice of another dentist, a new, well-fitting acrylic resin denture had been made that the patient now wears without any symptoms. This new upper acrylic resin denture was strapped to her forearm for forty-eight hours. Redness, papules, and vesicles appeared at the points of pressure of this new acrylic resin denture, which was causing no oral symptoms (Fig. 1). Indeed, I was able to reproduce these nonspecific pressure effects by strapping a jar cover made of tin on her forearm for forty-eight hours. After histologic examination of one of these vesicles, it was reported as a subepidermal bulla. Patch testing with the acrylic monomer showed negative results.

This patient, then, who had been informed that she was allergic to acrylic resin dentures because of a positive reaction of redness and vesiculation caused by strapping an acrylic resin denture on her forearm for forty-eight hours, had no difficulty in wearing properly fitting acrylic resin dentures. The vulcanite dentures and her rubber showed negative results. This patient has a moderately severe anemia, and the oral symptoms were caused by trauma.

CASE 6.—A woman, aged 65 years, had been informed that she was allergic to acrylic resin denture material on the basis of a positive patch test to her denture. At the time of examination she was using a vulcanite denture and her symptoms of burning and soreness in the mouth continued. Even when the dentures were not used, the symptoms were not much improved. Patch testing by applying a vulcanite denture on the left arm and an acrylic resin denture on the right arm for forty-eight hours resulted in redness and papules at the site of maximum pressure on both arms. Patch tests with acrylic resin monomer and several types of rubber showed negative results. This patient has a moderately severe anemia, and there is a possibility that the symptoms were caused by the anemia.

CASE 7.—A woman, aged 50 years, had been suffering from sore mouth due to dentures for three years. For many years she also had had recurrent aphthae of the oral mucosa. Three years ago, after she acquired a new set of acrylic resin dentures, her mouth became very sore. The acrylic resin dentures were then relined with the self-curing material. Immediately, the mouth symptoms became worse. She then changed to vulcanite dentures with some improvement; however, the aphthae and burning sensation in the mouth continued. Recently, because she did not like the appearance and feel of the vulcanite dentures, she did not wear them, and changed to a new set of acrylic resin dentures which she is now wearing without any difficulty, except for the aphthae. Patch tests with the acrylic resin monomer elicited a strongly positive reaction. A patch test with the acrylic resin denture showed some redness and papulation at the point of pressure. A patch test with the heat-cured acrylic resin disk was negative. Patch testing with the self-curing disk showed a true eczematous positive patch test characterized by redness, swelling, and fine vesiculation. Patch tests with several rubber materials gave negative reactions.

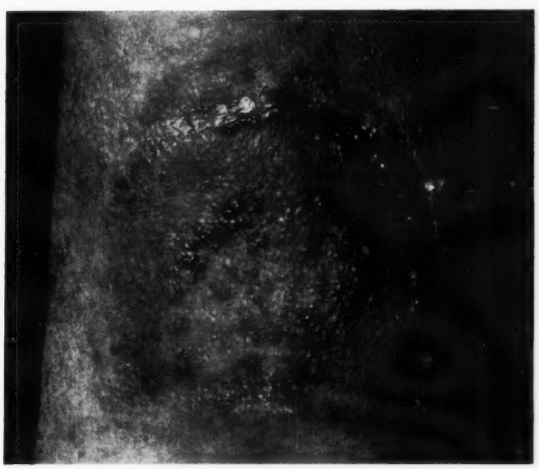

Fig. 1.—The results of strapping an acrylic resin denture to the forearm of the patient for forty-eight hours (Case 5). Evidence of a nonspecific pressure effect is seen, and not one of allergic sensitization.

In retrospect, I feel that the patient was not allergic to her original acrylic resin dentures. Apparently, they did not fit well. The relining material used to remedy the ill-fitting dentures apparently had enough unpolymerized monomer to cause an acute stomatitis venenata. A positive patch test to the liquid monomer showed that the patient had allergic sensitivity to this substance; however, she can now wear, without difficulty, well-fitting acrylic resin dentures in which the monomer is completely polymerized. This is further borne out by the negative patch test to the heat-cured acrylic resin disk, while a positive reaction was obtained by testing with the self-curing disk which has enough residual monomer to cause a positive reaction.

CASE 8.—A woman, aged 53 years, had burning of the mouth and glossitis of two years' duration. Examination of the oral mucosa had showed slight diffuse redness. Patch testing at that time with her entire upper denture was said to have been positive, and she was told to change her dentures; however, she could not afford to get new dentures and continued to wear the old ones. One year later,

after a cholecystectomy, all the oral symptoms disappeared in spite of the fact she was wearing her original acrylic resin dentures. Patch testing to the monomer and acrylic resin disk was negative. Strapping her denture on her forearm for forty-eight hours resulted in redness and papulation and a few large bullae (Fig. 2). These bullae I interpret as being caused by a nonspecific pressure effect. Furthermore, these bullae could be reproduced by use of a vulcanite denture. Histologic examination showed a subepidermal bulla.

Fig. 2.—A bullous reaction to testing with an acrylic resin denture (Case 8). The reaction is caused by a nonspecific pressure effect.

In addition to these 4 patients, 16 additional patients who had sore mouth due to dentures were studied. Each patient was patch tested to the following materials: (1) acrylic resin monomer, (2) the powdered polymer, (3) the heat-cured acrylic resin disk, and (4) the self-cured acrylic resin disk. All these tests were negative for a true allergic eczematous reaction. In very hot weather most of the patients showed a nonspecific, follicular, prickly-heatlike eruption upon removal of the disks. In addition, each patient had her upper denture strapped to her forearm for forty-eight hours. There were no true reactions of allergic sensitization. I interpreted all the reactions noted as being due to nonspecific pressure effects. Where bullae formed and were studied histologically, the report was subepidermal bullae without any eczematous reaction (Fig. 3).

In order to ascertain whether the liquid monomer was a primary irritant, 100 consecutive patients were patch tested with this material. These were patients seen in the allergy section who did not wear dentures but were being tested for other conditions. In only one of these patients was there a slight erythema after

forty-eight hours. I did not retest with the monomer to see how many patients I could sensitize.

In addition, I strapped an entire upper acrylic resin denture, for forty-eight hours, on the forearms of 20 male and 50 female control patients who did not have any mouth symptoms. In 2 men and 12 women, small bullae formed under the dentures. In all cases there was some degree of redness and papulation upon removal of the dentures; there was more in the women than in the men. Histologic examination of the lesions showed subepidermal bullae. There was no apparent eczematous change. Therefore, I interpreted these bullae as being caused by simple pressure effects, and not by allergic sensitizations. Furthermore, in no case did the erythema, papules, vesicles, or bullae spread beyond the points of maximum pressure, as often happens in true allergic eczematous reactions.

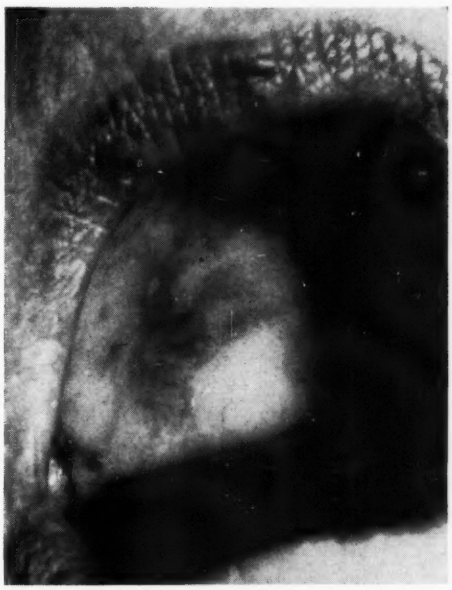

Fig. 3.—The bulbous reaction is due to pressure and is *not* an allergic reaction.

COMMENT

In this series of 20 patients with sore mouths caused by dentures, no patient was allergic to the completely polymerized acrylic resin denture. In this group there was one case of allergic hypersensitivity to the acrylic resin monomer. However, this patient could wear her acrylic resin dentures providing no unpolymerized monomer was present in the relining material. This agrees in the main with the finding of Nyquist[8] who could find no case of allergic reaction in 248 patients with sore mouths caused by dentures.

I must emphasize at this point that the clearing of a stomatitis when a denture is not worn and the prompt recurrence of a sore mouth with the use of the denture are no proof of allergic sensitization to the denture. Pressure and trauma of an ill-fitting denture may result in the same symptom complex.

Rattner[9] reported three cases of stomatitis venenata that he attributed to the wearing of plastic cellulose dentures. He was among the first to employ the method of testing the dentures by strapping the entire denture on the patient's forearm and leaving it in place for twenty-four to forty-eight hours. Bradford[10] described an unusual case of stomatitis with a generalized erythematous eruption that appeared soon after the patient acquired a new set of acrylic resin dentures. After the eruption had subsided, a skin test was carried out by strapping the denture to the forearm. Within forty-eight hours, a rash appeared at the point of contact of the acrylic re. 'n denture and the skin.

Most of the authors already mentioned discuss allergic reactions to acrylic resin dentures. The consensus is that while such allergic sensitization possibly does exist, the incidence is very low. All of these authors indicate that patch testing with the entire denture or with scrapings from the denture is the proper method for detecting such allergy.

Beall and Caul[11] reported reactions to the self-curing acrylic resins used for lining dentures. By means of a questionnaire, they learned that 88 per cent of the dentists reported that their patients complained of a burning sensation after the use of a relined denture. The discomfort lasted from a few hours to a day or so. There was no indication of allergic sensitization to this material in this report, since the patients continued to use the relined dentures without difficulty after the inital burning sensation had disappeared.

Vickers[12] reported seven cases of angular fissure formation with some degree of stomatitis that were presumably caused by sensitization to dentures. Scrapings from the suspected dentures were applied for forty-eight hours, and there was no difficulty in reading the results. Some of these patients apparently wore acrylic resin dentures; others wore vulcanite dentures. Stoy,[8] however, patch-tested all patients with suspected angular stomatitis, but reported that he had obtained no obvious positive patch tests, and could not prove that any of his cases of angular stomatitis were due to sensitivity to the acrylic resin dentures. I similarly studied eight patients with perleche (angular stomatitis), and in none could I prove that the acrylic resin dentures were the cause of the angular stomatitis. In four patients who did not wear the dentures for two weeks, the angular stomatitis remained unimproved. In all eight patients there was no evidence of allergic sensitization by patch testing to the acrylic resin monomer.

Nyquist,[8] in his recent treatise on sore mouth caused by dentures, found that patch testing with grindings or scrapings from the suspected dentures incurred the least risk of mechanical lesions of the skin. He admits that testing with the entire denture or pieces of the denture might give false reactions in the form of erythema of the patch test site, which could be confused with a true allergic reaction.

I also believe that patch testing by strapping the entire denture to the forearm may lead to many diagnostic errors, since redness, papulation, vesiculation, and even bulla formation may result from nonspecific pressure effects. To the uninitiated, such findings may be easily confused with a true allergic reaction. Furthermore, there seems to be no necessity for testing with an entire denture or even with grindings from the denture, because the completely polymerized resin is allergenically inert. My results show that patch testing with the liquid monomer

alone is sufficient to indicate the presence or absence of allergic sensitization to acrylic resin denture material. The polymer and the heat-cured denture have not been shown to be sensitizers.

Persons who are highly sensitive to the monomer may nevertheless wear acrylic resin dentures, providing the monomer has been completely polymerized. Spealman and his co-workers[13] showed similarly that 10 experimental subjects, whom they had sensitized to the monomeric methyl methacrylate, were not allergic to the completely polymerized product (in this case Plexiglas) in spite of the fact that the finished product was made with the monomer.

In those cases in which it is suspected that relining or repair material made with self-curing dental resin is causing symptoms, patch testing with the liquid monomer alone is sufficient. The positive patch test with the liquid monomer would tend to confirm the implication that the relining material was at fault. A negative patch test to the liquid monomer would seem to rule out the role of allergic sensitization to either the heat-cured denture or the self-curing material.

I feel that there is apparently no necessity for testing the liquid monomer directly on the oral mucosa. Many workers, including Jadassohn[14] and Sulzberger and Goodman,[15] have shown that the oral mucosa may be the site of allergic reactions analogous to the allergic eczematous contact reaction of the skin. Goldman and Goldman[16] showed, by direct oral mucosal contact testing, the close similarity of the reaction of the skin and mucosa. These authors concluded that contact stomatitis is usually associated with contact cutaneous allergies, actual or potential. In my studies[17] of the allergic contact type of reactions to tooth paste, I have found that the oral mucosa and the perioral skin and the skin of the extremities react similarly. The ingredients suspected clinically as causing the oral symptoms were revealed by positive patch test on the skin. While such a relationship is not invariable, patch testing of the skin can usually be relied on to indicate sensitivity of the oral mucosa as well.

SUMMARY

Four patients were studied who had an allergic contact type of dermatitis of the hands that was proved clinically and by patch testing to be due to allergic sensitivity to the liquid monomer (methyl methacrylate). These patients were not allergic to the polymethyl methacrylate powder or to the heat-cured denture material. Two of these patients could wear acrylic resin dentures in spite of the fact that they were sensitive to the monomer. They were also sensitive on patch testing to denture material made with the self-curing monomer, showing that with this material there is sufficient unpolymerized monomer that can produce reactions.

Twenty cases of sore mouth caused by dentures were studied. Four of these patients had been told that they were allergic to their acrylic resin dentures because of positive reactions obtained by strapping their dentures on the forearm for forty-eight hours. Three patients changed to another type of denture without relief. One of the patients was found to be allergic to the monomer but could wear a heat-cured acrylic resin denture without difficulty. In none of the cases could I prove that allergic sensitivity to acrylic resin denture material played a role in sore mouth caused by dentures. Seventy controls, 20 men and 50 women,

had dentures strapped on their forearms. In forty-eight hours all reacted with some degrees of redness and papulation. In 2 men and 15 women, small bullae formed at points of maximum pressure. Histologic examination showed subepidermal bullae without eczematous response.

CONCLUSIONS

Methyl methacrylate liquid monomer is a sensitizer and can cause an allergic contact type of eczematous reaction on the skin and the oral mucosa. When it is completely polymerized, it is no longer a sensitizer or elicitor of allergic reactions. No instance of allergic sensitization to heat-cured acrylic resin denture material was found in 20 patients with sore mouth caused by dentures. Self-cured acrylic resin denture material has sufficient unpolymerized monomer to give reactions in patients sensitized to the monomer.

Testing for allergic sensitization to acrylic resin denture material by using the entire denture or with grindings or scrapings of the denture is unnecessary, since testing with the monomer alone will indicate the presence or absence of allergic sensitization to the denture material. The polymer and the completely polymerized material apparently are not sensitizers. Many persons will react to the strapping on, for forty-eight hours, of any type of denture on their forearms with redness, papulation, and even bullae formation. This appears to be a nonspecific pressure effect, since histologic examination of these bullae showed simple subepidermal bullae without any eczematous reactions.

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ESTHETICS AND THE DENTURE BASE

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THERE IS NO EXCUSE FOR dentures which could be classified as "false teeth" from appearance alone,[1,2,3,5] yet a high percentage of dentures inserted today fall far short of restoring not only dental function but facial appearance as well. It is common practice to allow dental laboratories to do much of the mechanical and structural work required in denture construction. The functional and physiologic phases of prosthodontics should be questioned and weighed in order to afford patients the best possible long-term denture service. Only one esthetic aim is necessary, and that is the reproduction of anatomic characteristics present before the natural dentition is lost (Fig. 1).

The two elements that must be considered in denture esthetics are the teeth and the denture base. The factors relating to the teeth are their form, shape, color, and arrangement. The factors relating to the denture base are the reproduction of the contours of the tissue covered by the base, and its staining to reproduce the natural tissue hues.

This article will be limited to the factors relating to the denture bases and a description of a simple procedure which will produce esthetic natural-appearing denture bases. This procedure is used by Tufts University Post-Graduate Prosthodontic Department, and is taught by Dr. Irving R. Hardy. Much of the credit for it should be given to Dr. Earl Pound, whose work and writings,[1,2] are the bases on which it has been evolved.

Patients often choose the smooth, highly polished denture base in preference to the natural-appearing one. This would seem to stem from a common human weakness of wanting any object which looks new and shiny. The natural-appearing denture, irregular and multitoned, is far less appealing when displayed out of its intended medium. Moreover most denture patients, having had previous dentures or having seen other patients' dentures, have a preconceived idea of what they desire. Since dentures with unesthetic bases are more numerous than those with esthetic bases, it is easy to see how this idea is established. Most patients readily see the advantages of natural-looking dentures after being informed by slides and models. Those who cannot be deterred from a foolish choice are given as close to what they desire as can be achieved. Because the mental attitude toward dentures is so important, the patient must not be forced to wear the dentures you pick; they must be the ones the patient wants.

Received for publication Dec. 22, 1955.

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INDICATION FOR ESTHETIC DENTURE BASES

The esthetic denture bases are indicated for (1) patients with an active upper lip, (2) patients with a prominent premaxillary process, (3) theatrical performers, singers, and others who may expose normally unobserved gum tissue areas during their performances, and (4) the psychologic effect on the patient and the dentist.

While the first three may be classified under variations in physical structure and function of facial anatomy, the fourth, the psychologic effect on the patient and dentist, cannot be overemphasized. We all know the tribulations patients go through after new dentures are inserted. Sincere dentists have their problems too, but from a different viewpoint. An initial displeasure of the patient with his appearance (before sore spots have even begun to develop) frequently makes function seem poorer and sore spots more numerous and severe. The complete upper denture against natural lower teeth is a graphic example. A denture that is difficult to detect, when seen with natural mandibular teeth and ridge anatomy, will do much to insure greater patient cooperation during the functional adjustment period than is obtained in cases where immediate visual differences are apparent. The dentist, being pleased with the dentures, the patient's reaction, and himself, will exert more effort to see that troubles following insertion are properly corrected.

Fig. 1.—This immediate maxillary denture shows that the anatomic contours shown in the study cast have been reproduced in the base.

Natural denture bases are obtained by (1) an esthetic wax-up which reproduces the contours of oral anatomy lost with extraction of teeth and alveolar resorption, (2) staining these contours to give them a vital appearance. One is of little value without the other.

THE WAX-UP

The structures included in waxing the maxillary denture are: the buccal and labial frenula, the gingival sulcus, the free gingivae or gingival margin (smooth surface), the attached gingivae (stippled surface), the interdental papillae, the root eminences, and the attachment of the mucobuccal (and labial) fold on the facial surfaces. The incisive papilla, the rugae, the lingual margin proximal to posterior teeth, and the contour in approximation with the anterior teeth are included on the lingual or palatal surfaces.

Extreme accuracy of wax-up is necessary. Excess grinding or polishing of the processed denture will remove the anatomic contours and staining. The wax-up does not require the skill of an artisan, as has been stated.[3] It requires simply the ability possessed by a competent dentist or dental laboratory technician. A No. 7 wax spatula is the key instrument used throughout the carving sequence. In order to reproduce rugae, a tin-foil pattern is made before the baseplate is secured to the cast. A double thickness of 0.003 gauge tin foil is placed over the rugae area of the cast and swaged with a pencil eraser to obtain adaptation. This pattern is removed and cut around the edge so the two thicknesses can be separated. The outer layer, containing imperfections caused by direct contact with the burnisher, is discarded. The second layer, in apposition with the cast, is trimmed accurately and put aside until the lingual wax-up is carried out. The corresponding baseplate area is also cut away at this time. Points on the cast where definite border width cannot be easily discerned are marked in pencil (Fig. 2). The baseplate, with the teeth set up, is waxed to the cast while it is still mounted on the articulator. This will reduce errors in the occlusion.

Fig. 2.—The border width, if indistinct, is marked on the cast so that wax in this area can be reduced to its proper thickness.

Excess wax is built up on all surfaces by softening small pieces of wax and pressing them into place, or by rolling a wax sheet into a strip, heating and adapting it to the base. The facial surfaces are shaped first. The border is trimmed back to the thickness determined earlier on the cast. The gingival margin or free gingival limits are formed by the removal of wax from the cervical portion of the teeth until sufficient areas of their labial and buccal surfaces are exposed. More facial tooth structure is exposed in aged patients to represent the normal physiologic gingival recession. The interdental papillae are left long and pointed for young patients, increasingly short and blunt for older patients. Alternate anterior papillae may be overshortened. When they are stained red later, they will simulate periodontal irritation. Elsewhere the margin is reduced to 0.5 to 1 mm. of labiolingual thickness and 1.5 to 2 mm. in width. Excess wax between the margin and the border, representing the attached gingivae and mucobuccal fold, is removed. While forming this portion, minor eminences are left over the root areas of the incisors, and heavy eminences are formed over the cuspid roots.

Gingival surfaces, proximal to the posterior teeth may show continuous alveolar bulk or minor root contours. It should be emphasized that the cuspid eminences are very prominent, all others being nonexistent or obvious only under careful examination. The gingival margin is accentuated by indenting it along the junction of the attached gingivae and the free gingival margin, blending the attached portion into this groove (Fig. 3).

The palatal surfaces should be contoured so that the patient can regain the maximum of the sensations of contour present before the loss of the dentition. The elements contributing to these sensations are the reproduction of the rugae, the vault form, and the anatomy of the tissues adjacent to the teeth.

Rugae.—The thickness of wax on the hard palate is reduced (where the baseplate has been removed) until the color of the cast just commences to become apparent through it. The tin-foil rugae pattern made earlier is placed in position, and its edges are sealed with a warm spatula. The reduction of wax until the cast color is visible through it creates minimal impingement on the tongue space by the vault surfaces.

Fig. 3.—Definition is given the wax representing the free gingivae (margin) by indenting it 1.5 to 2 mm. superior to the cervical base limits and blending the wax of the attached gingivae into this groove.

Base-Anterior Teeth.—A common error in contouring palatal surfaces is burying the cingula of anterior teeth in the acrylic resin. The lingual surfaces of the anterior teeth should be given a natural cingulum form and lingual anatomy by contouring the wax adjacent to them, to the extent allowed by ridge-tooth and ridge-ridge relationships.

Base-Posterior Teeth.—The maxillary bone structure of skulls shows a moderate thickness of alveolar process lingual to the teeth (in fact, it is thicker than that on the buccal side). This is recreated in the denture by leaving 0.5 to 1 mm. of buccolingual thickness of the wax alveolar crest between the teeth and the lateral alveolar processes during wax-up (Fig. 4). The base does not terminate flush with the lingual surfaces of the teeth.

Take extreme care when acrylic teeth are used not to overheat them, and lightly flame the wax surfaces with a Hanau torch to eradicate the carving marks, leaving a semismooth finish which shows the *basic* form of the hard tissue anatomy.

Frenula.—The wax labial frenum extends from the gingival margin between the central incisors to the mucolabial fold adjacent to the labial notch made by the natural frenum. Narrow and thin at the margin, it broadens and thickens as it approaches the fold. The buccal frenula arise from a marginal point between the first and second bicuspids and fan posterosuperiorly to a broad thick band at the mucobuccal fold. A small amount of wax melted on the fine end of the No. 7 spatula is drawn from the fold toward the marginal termination point. Wax bulk will be greatest where the spatula is first applied, and minor carving to give the frenula definition is all that is done.

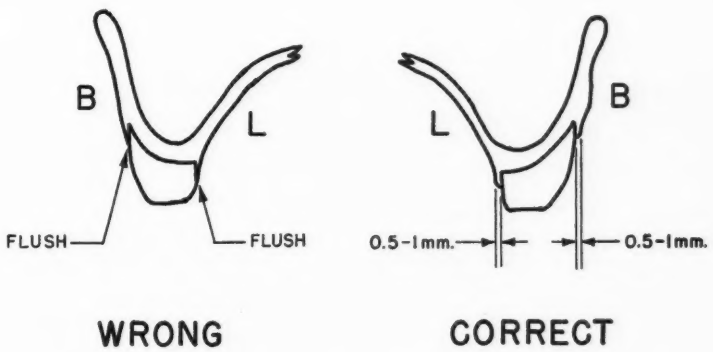

Fig. 4.—Five-tenths to one millimeter of buccolingual width is left between the lingual surfaces of the posterior teeth and the lateral alveolar processes. Nowhere on the facial or lingual surfaces does the denture base terminate flush against the teeth.

Stippling.—The surface of natural attached gingivae appears rough when it is wiped dry. This stippled effect is produced on the denture by the use of a stiff-bristled toothbrush, trimmed to one shortened cross-row of bristles so that its application can be well controlled. The stippling terminates just posterior to the last tooth in the arch. The width of the stippled area is optional, but 1 cm. is the maximum width ever necessary. Stippling acts to blend the individual anatomic components and causes an uneven light refraction, which is an important factor contributing to naturalness.

Gingival Sulcus.—Numerous denture wearers show the area comprised of the gingival margin, gingival sulcus, and cervical portion of the teeth. The flat, blunt junction of the denture base and the tooth, so commonly seen, is both unnatural and unsightly. The production of a slight bulk of gingival margin and the minute break between it and the teeth affords an appearance which is far more natural. The sulcus is produced by inserting a No. 23 explorer tip, or similar sharp instrument, between the tooth and the wax at the gingival margin, and moving it

mesiodistally along this junction (Fig. 5). All components of the form having been completed, the wax surfaces are buffed with a silk cloth, repeatedly dipped in cool water to produce a hard, polished surface on the wax (Fig. 6).

Fig. 5.—The gingival sulcus is formed by inserting the tip of a No. 23 explorer between the tooth and the wax, then carrying it mesiodistally along the cervical end of the tooth.

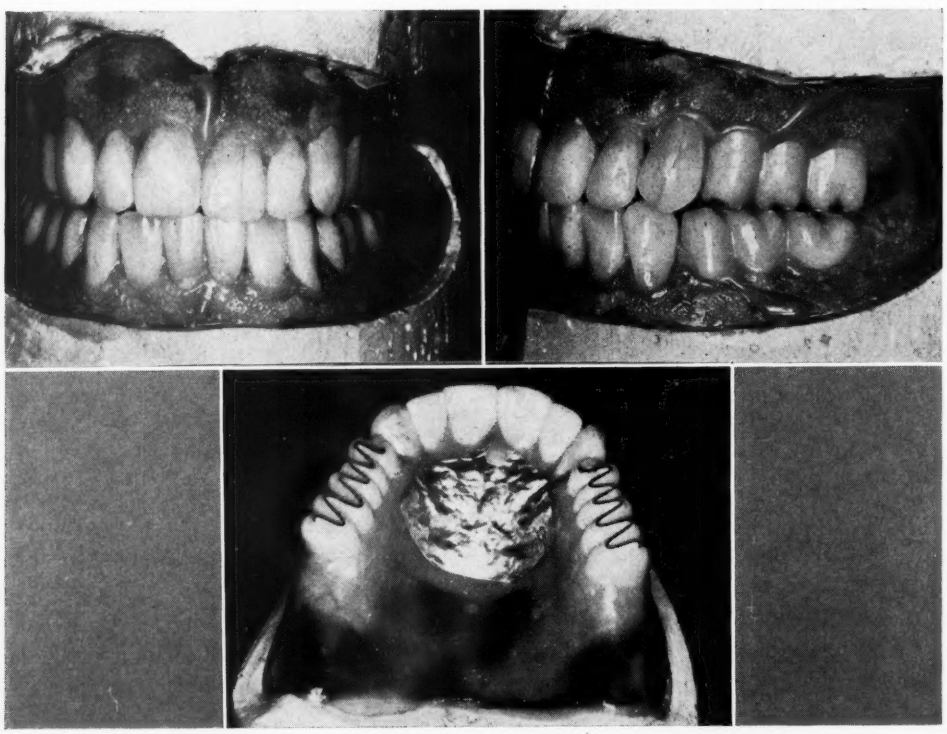

Fig. 6.—Buccal, labial, and lingual views of the waxed-up denture ready to be removed from the articulator and invested.

The mucous membrane covering the labial surface of the alveolar ridge with the dentition still present may appear to be relatively smooth, but when it is reproduced on a dry cast, it will show a surprising amount of irregularity. This factor of environment applies to the denture base also. Denture base contours, and irregularities of tooth arrangement which seem to be overemphasized when they are observed out of the mouth will be found to blend and appear normal

when the denture is in the mouth. The saliva, the hues and tones of the surrounding oral tissues, the contours of intraoral structures, and the low visibility in the mouth contribute to this illusion. Experience will serve as the guide for the development of contours which are neither too weak nor too severe.

INVESTMENT

There are two requirements of the investment procedure: (1) The reproduction of the anatomic contours must be definite. (2) There must be a minimal change in dimensions of the cured denture.

The cast is freed from the articulator mounting. Its base is trimmed so that the anterior segment will approach the perpendicular when it is seated in the flask. The presence of any extreme labial projection which might chip the investment material or cause excessive displacement of stain during final closure is thus prevented. Plaster, carried flush with but not onto the wax border, is used to invest the cast in the lower flask half. When this plaster has set, it is carefully coated with petroleum jelly. Care should be taken to prevent the petroleum jelly from getting on the surface of the wax as it will destroy detail. The base and teeth are painted with Debubblizer or other wetting agent. A medium mix of hard-setting dental stone is brushed onto all wax surfaces with a No. 3 round camel's-hair brush to a depth of approximately $\frac{1}{8}$ inch (Fig. 7). Brushing assures its penetration into the stippling and interproximal spaces with no air entrapment.[4] The stone overlay serves two functions. It reproduces detail accurately and forms a hard bulk which will maintain the teeth in their correct relation to the ridge and thus reduce distortion.[7] The exposed surface of the stone is left irregular and a thin coating of petroleum jelly is applied so that mechanical binding of the stone to the final plaster layer is achieved without a maximum union between the two. The upper half of the flask is placed in position and filled with plaster.

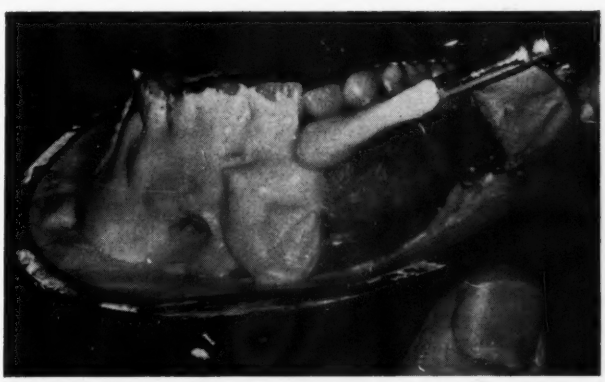

Fig. 7.—A stone overlay is brushed onto the facial and lingual wax surfaces to insure an exact, bubble-free reproduction of the anatomic detail.

When sufficient setting time has elapsed, the flask is placed in boiling water for five minutes, gently separated with a Gritman plaster knife, and rinsed with boiling water to wash out any remaining wax. The opened flask should not be

washed excessively or immersed in hot water. It has been shown that such treatment will destroy some detail.[6] The tin-foil rugae pattern is removed, and any roughness where its edges were in contact with the stone investment is smoothed off. A "flash groove" is cut into the plaster around the cast. While still hot, both halves of the flask are painted with a chemical-alginate separator. Caution is taken to obtain good coverage around, but not over, the cervical ends of the teeth. Diatoric holes are drilled in the cervical ends of the acrylic teeth if none are present. Base acrylic resin will be forced into these holes and provide mechanical, as well as chemical, union of teeth to the denture base. The flask is allowed to cool. A minimum of two trial packs are made, removing all flash each time. A neutral shade of acrylic resin is used. This has a pale pink color

Fig. 8.—An upper denture packed and ready for staining on exposed facial and lingual surfaces of the uncured acrylic resin.

which is homogeneous with tissue hues midway between the deep and pale extremes found in the oral cavity. Austenal Vitalon "Tissue Tone" 10-60 has been found to give the best color balance. An important variation from standard procedure is incorporated in packing the flask. Plastic or cellophane trial pack sheets are placed between the teeth and the acrylic resin being packed, and *not* between the cast and the resin. The final trial-pack separation finds the acrylic resin adapted to the cast, with an anatomic reproduction of the lingual and facial surstaining procedure will be carried out. The upper half of the flask, bearing the faces which are exposed (Fig. 8). It is on these acrylic resin surfaces that the teeth, is freed of any excess acrylic resin, recoated with separator, and set aside.

The staining procedure to be described reverses that suggested by Pound.[1] He applies the stains on the stone investment surfaces before any packing is done. Since he works from the denture surface inward, all stains must be applied in reverse order, the one representing the outer surface being applied first.

Two difficulties are encountered in this method: (1) It is impossible to predict the results or to correct errors of application since the effect of adding the stains cannot be observed. (2) The repeated addition of monomer directly against the separating medium may result in the investment material adhering to the base acrylic resin when the denture is deflasked.

Pound's procedure is superior, however, when porcelain pin anterior teeth are used. The pins penetrate the cellophane sheets used in trial packing, and a large amount of acrylic resin is forced around the necks of the teeth during the trial closures. This resin cannot be removed completely, and it obliterates much of the stain applied by the procedure to be described. This does not occur when dentures are stained by Pound's technique, since the stain is applied before any packing is done.

STAINING

In staining the denture base to simulate natural tissue, three factors must be considered in relation to actual oral conditions:

1. Variations of color are affected by the extent of vascularity within the tissue.
2. The thickness and density of the soft tissue act as secondary factors in altering tissue hues. Greater soft tissue thickness will produce deeper hues, while greater soft tissue density tends to be found in lighter tissue.
3. The cellular components of a tissue will alter its color.

While colors and hues in each mouth may vary in one area or another, an evaluation of a large group of patients breaks down into the following pattern:

Deep (red) tones are found in the mucobuccal fold, frenula, soft palate, pharyngeal soft tissue adjacent to the tuberosities, incisive papilla, interdental papillae, and the larger rugae.

Pale (yellow) tones are found in root eminences and the hard palate.

Neutral (pink) tones which fall between the extremes of deep and pale tones are located on the lingual side of the lateral alveolar processes, and facially in the fan-shaped areas, between root eminences, that diverge toward the mucobuccal fold.

This staining technique is formulated around these three basic colors.

The armamentarium for staining consists of three items (Fig. 9).

1. A set of five bottles of stain (variously colored acrylic resin):
   a. Red stain—Kay See #279.*
   b. Yellow stain—Kay See #212.*
   c. Two bottles for blending and vascularity. These consist of neutral pink polymer (used in the initial base packing) with ⅛ to ¼ inch long red nylon fibers added.† The fibers are added sparsely in one bottle, and in large amounts in the other bottle.

*Kayon Denture Stains, Kay-See Dental Manufacturing Co., Kansas City, Mo.
†Austenal 10-60 Polymer, Austenal Laboratories, Inc., New York, and Chicago.

d. Blue, brown, or a suitable combination of the two, to be used for patients showing melanotic pigmentation.* The dispensing bottles may be doll nursing bottles or small liquid vitamin bottles with Vinethene dispenser caps affixed to control the flow.

2. A hypodermic syringe equipped with a No. 21 needle, or a used disposable penicillin cartridge-needle combination to which a rubber squeezer has been attached.
3. A small bottle to hold the monomer.

Fig. 9.—The staining kit is composed of stain dispensers, syringe, and a small bottle to hold monomer.

Other stains were tried and rejected, either because the polymer was coarse enough to affect the surface, or because the completed denture showed little or no variation of hue.

Procedure.—Each stain is applied wherever it is to be used before the next stain is added. Precaution should be taken to keep the needle which carries the monomer and the stain dispenser tips out of contact with the acrylic resin and deposited stain in order to avoid clogging the needle or the dispensing bottles. A definite sequence in application is followed. This consists of moistening the section to be stained with monomer, adding the stained polymer, and carefully moistening the powder with monomer.

Yellow: The flask is held so the surface of the resin to be stained is up. The resin is moistened with a few drops of monomer from the syringe. The yellow stain is gently shaken onto the root eminences. (The colors of the gingivae of the labial surface are lightest over the cuspids, with less lightness over the incisors. Only a slight amount of the yellow stain is used over the incisor eminences, and a much heavier amount is used on the cuspid eminences.) The stain is carried over the gingival margin around each tooth and into the indentations left in the base resin by the necks of the teeth. Thus, the paleness is made to extend to the cervical portion of the tooth. The area of the stain is wide at the margin of each tooth, and it tapers off to nothing in the region of the attached gingivae as it ap-

*Kayon Denture Stains, Kay-See Dental Manufacturing Co., Kansas City, Mo.

proaches the mucobuccal fold. After the polymer has been applied, it is moistened carefully so the site of its placement is maintained.

On the buccal surfaces, the yellow stain may be placed over each root area if an impression of eminences is to be created, or the stain of each root may be joined to that of the adjacent ones if an illusion of continuous alveolar bulk is desired. Then the yellow stain is applied over the rugae and hard palate.

Red.—The red stain is applied separately to each of the three frenula. A light application of the red stain is a necessity. Small amounts of red are obvious on the processed denture. Extreme care must be exercised to see that the stain is confined to the surface of the frenum and that it is not spread mesiodistally. The denture will show disproportionately red areas proximal to the frenula if the stain is carelessly applied.

The portion of the denture between the border and the portion representing the attached gingival tissue is stained one surface at a time. Its color will blend with the stain applied to the frenula.

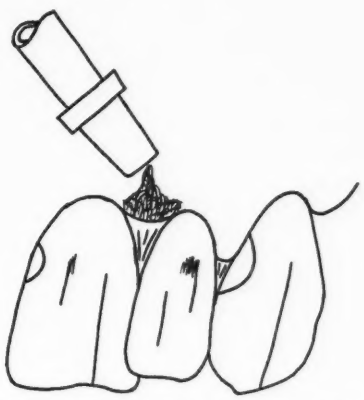

Fig. 10.—Red stain is added to shortened anterior interdental papillae to simulate periodontal irritation.

The stain is applied by the monomer-polymer-monomer sequence on the incisive papilla, over the prominent rugae, and on the tuberosities to give the appearance of pharyngeal soft tissue attachment. Finally, red stain is added along the posterior border of the denture where hard and soft palates join. This should be done only after it has been determined that the post-dam area is in such relationship to the soft palate that staining here will not create an isolated red streak in the roof of the mouth. Addition of this stain allows the posterior limit, which often is a straight line from one tuberosity to the other, to be made irregular and less conspicuous.

Any special stains which are to be added to labial or buccal surfaces are applied at this time. These may include red on properly formed interdental papillae to simulate periodontal tissue irritation (Fig. 10), dark stain on selected hard tissue areas to create the appearance of melanotic tissue for patients who reveal this trait, and a light application of yellow stain over all surfaces of dentures for yellow-skinned patients.

The two neutral polymer stains are used last (Fig. 11). One surface at a time is moistened, and the polymer which contains few fibers is applied liberally over all areas stained yellow or not stained at all. The polymer which contains many fibers is applied just as liberally over all areas where red stain has been applied. The application of the neutral polymers in this way serves two purposes: (1) It obliterates the lines of sharp demarcation of the individual stains so only moderate undertones remain. (2) The nylon fibers will appear as blood vessels, being denser in the red areas where more fibers were added.

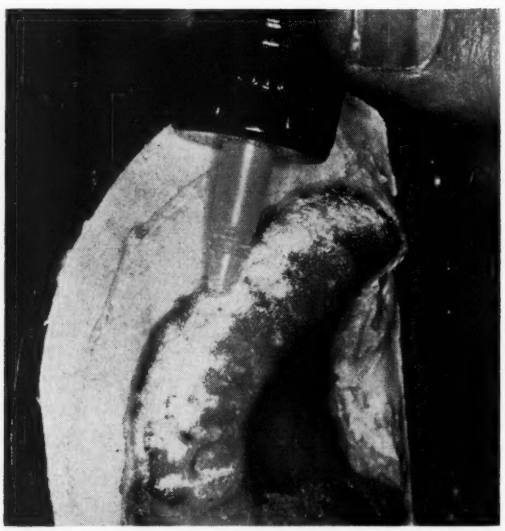

Fig. 11.—A heavy layer of neutral (pink) polymer with nylon fibers is added to blend the individual colors and produce the appearance of vascularity in the denture base.

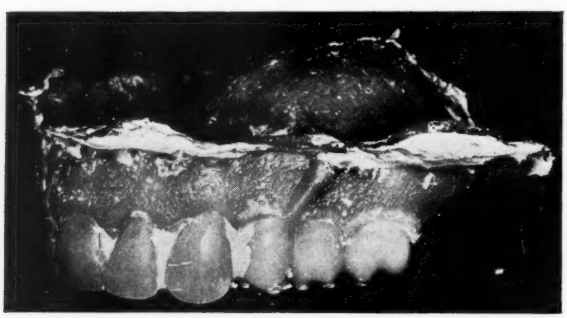

Fig. 12.—A maxillary denture just removed from its investment. No débridement whatever has been done. A proper application of the separating medium prevents the investment from adhering to base acrylic resin.

Special care is necessary in bringing the two halves of the flask together because of the correlation of form and color. Minimal displacement of colors, particularly in the more conspicuous anterior segment, is achieved by inserting the anterior ridge portion down and inward, then bringing the back end of the flask together. The flask is placed in a press and cured by the slow cure method.

The investment will break away from the denture with little effort after curing if the separator has been properly applied (Fig. 12). Only minor finishing is necessary. The flash is removed with a white stone, and a strong pointed tool, such as the sharpened shank of a broken hand instrument, is used to remove debris from between and around the cervical portion of the teeth. The denture is polished on all surfaces except the borders with a small bristle brush and pumice on a lathe running at slow speed. A soft rag wheel is used on the borders. The final lustre is obtained by using tin oxide and a soft bristle wheel on the lathe (Fig. 13).

Fig. 13.—Completed dentures with nonanatomic and anatomic bases (above) on bench and (below) inserted in mouth.

SUMMARY

There is no excuse for producing an unesthetic denture base with the materials which are available. A simple sequence of procedures is all that is required. This consists of an anatomic wax-up of the base, proper investment and packing, and staining with three basic stains to imitate the natural tissue tones. The time consumed in these procedures is insignificant when the quality of the final product is considered.

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THE BIOLOGIC SIGNIFICANCE OF HINGE AXIS DETERMINATION

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FOR SOME TIME THE controversy about the "centric" position of the mandible has been waged with much wordage but without decision. The question centers around the relation of mandibular condyle to the temporal bone (articular fossa) in the "normal" or desirable or harmonious occlusal position, called by most authors the centric, by some the "true" centric, position of the lower jaw. It seems necessary to stop for a moment and to forget the contradicting statements, and to investigate instead the biologic, that is, the anatomic and physiologic principles that underlie or, more correctly, should underlie the discussions of these problems. Though no decision is intended in this article, it is hoped that it will clear the air of much loose talk and prepare the ground for a sound evaluation of facts, both basic and clinical.

The hinge position, or terminal hinge position, is that position of the mandible from which or in which a pure hinge movement of a variably wide range is possible. Since in such a movement the automatic protrusive action of the external pterygoid muscle has to be counteracted by a voluntary contraction of all or most of the retrusive muscles, the mandible is pulled into its most retruded position, and, since the retrusion is carried out by muscular action, it is necessarily an unstrained position as far as the temporomandibular joint is concerned.

Centric position of the mandible is best defined as the ideal, totally harmonious, or balanced occlusal position, in which not only all the teeth are in proper contact but also the joints and their muscles are in equilibrium.

In contrast to the latter position, the median occlusal position has to be defined as the position in which all the teeth are in full contact, regardless of the state of the muscles and joints. In this position the mandible itself may, and often is, displaced from its ideal, that is, centric position.

For quite some time the question has been discussed as to the relation of condyle (and disc) to the temporal bone in the ideal, i.e., in the centric position. Some authors identify centric and hinge position and state, therefore, that in centric position the condyle is in its most retruded position in the articular fossa. Several additions, such as "unstrained" or "from which free lateral movements are possible," are sometimes added, unnecessarily it seems.

Others maintain that in its ideal or centric position the mandible is slightly in front of its most posterior position. Therefore, a retrusive movement of 0.5

Read before the American Denture Society, Feb. 4, 1956.
Received for publication Jan. 27, 1956.

to 1 mm. from the median occlusal position is not only possible, but indeed a sign of normal relations between the mandible and the temporal bone. It is added, however, that this retrusive movement is absent or at least cannot be measured in a few individuals who otherwise appear to be entirely normal.

In view of the controversy as to these questions it seems appropriate to analyze the biologic significance of the hinge position, since its clinical advantages are hardly to be denied, especially in the construction of complete dentures.

For many decades, it was good practice in complete denture construction to establish occlusal position in the most posterior position of the mandible. A number of "tricks" were used to make the patient "bite" into this position, for instance, maximal backward bending of head and neck, supine position, swallowing while closing, etc. More accurate results were obtained by registering the apex of a needle-point tracing, and finally by determining the hinge axis. In executing a number of lateral movements, the patient automatically pulls the jaws into the most posterior position because he is finally led into the *extreme* or *borderline movements*. From then on, the movements, at first erratic, become definite and are exactly repeated over and over again. That the determination of the hinge axis can be done only in the most posterior position of the mandible has been explained before.

When it was certain that a complete denture, constructed under the guidance of the hinge axis, was by far more acceptable to the patient and, functionally, by far superior to any denture constructed in a more anterior relation, the question arose as to the reason for this evident success. The first answer, which presents itself with tempting ease, was the statement that the hinge position, i.e., the most "retruded" position of the mandible, is the centric position—the optimal physiologic position.

SIGNIFICANCE OF THE HINGE POSITION

In order to avoid rash conclusions and to understand the real significance of the hinge position, we have to study the normal automatic closing movement of the average individual with a full and normal dentition. If one opens the jaws wide and then snaps the jaws shut, the closing muscles pull the jaw unerringly and unhesitatingly into the median occlusal position. In a mouth with a normal or even with an average dentition, there is no meeting of cusps on inclined planes, no gliding along these surfaces, no "premature" or "initial" contact, but an instantaneous and correct intercuspation, vertical and horizontal overlap. In median occlusal position, the condyles, in the overwhelming majority of individuals, are slightly in front of their "most retruded" position. The controversy whether this is equal to centric position or whether it is to be diagnosed as an anterior displacement is irrelevant for the present discussion. What is important is the fact that in this, the median occlusal position, the temporomandibular joint is not in a marginal position—in other words, the capsule is not in a state of unique tension but is in all its parts more or less relaxed. This in turn must be interpreted as ruling out proprioceptors of the capsule as directing the automatic closing of the jaws. The only guiding signals are the proprioceptive stimuli originating in the periodontal membranes. If the upper and lower teeth are brought into full contact, that is,

in median occlusal position, the sum total of periodontal stress and, therefore, the sum of all periodontal proprioceptive stimuli is wholly unique and of an unsurpassed exactness and accuracy. But, one will ask, since these stimuli are set off only at the moment of closure, how can they *lead* the movement *into* closure exactly in the median occlusal position?

We have to remember that a directed movement, such as that described, is not unique in our body. Neurologists, testing proprioceptive nerves and neural pathways, have long since used a simple movement among their battery of tests. The patient, with his eyes closed or bandaged, is asked to touch the tip of his nose with the tip of his forefinger. If there is no nervous disease, he will be able to do so without any difficulty—but still with some slight variation that may amount to 2 to 3 millimeters to one side or the other. Here again, proprioceptive signals play the role of leading the movements of shoulder, elbow, wrist, and finger into a certain efficient, though not unequivocally exact, position. These stimuli, forming in their totality a recognizable and retainable pattern, arise, of course, in all participating muscles and joints. This pattern must be retained in the "memory banks" of our brain, in all probability in what neuroanatomists know to exist as closed neuronal circuits, quite comparable to circuits in an electronic computer, often referred to as an electronic brain. Evidently, as proved by the experiment, this proprioceptive memory is efficient enough, but not in any way as accurate and precise as that leading the muscle action in mandibular closure. The exactness of this movement depends on the precision of periodontal load, by far surpassing that of muscle tension or stimuli in a capsule that is not in an extreme (and therefore unique) position. The "memory" of the periodontal stimulation in median occlusal position leads, therefore, during automatic closure of the jaws, by a feedback to the acting muscles.

One more fact, however, has to be taken into consideration. The "engram," that is the neuronal representation of the proprioceptive memory, cannot be rigid and perpetual. The eruptive movements of the teeth, their attrition followed by mesial drift, and other changes of their position make it unquestionably necessary that this "engram" changes almost continually. In this behavior, such an engram does again duplicate electronic circuits that have to be "reinforced" or re-established ever so often if they are to function as part of a memory bank. In the case of closing the jaws, this reinforcement takes place every time we close into the median occlusal position in *automatic* closure of the jaws, for instance, during swallowing.

However, the necessary adaptability of the closing movement has, as a consequence, a rather fast fading out of the existing engram, so that it may be changed into the new pattern that is as exact as the old one.

Thus we arrive at the inevitable conclusion that an edentulous patient is an individual whose mandibular musculature has lost its precise guiding signals, especially in the closing movements of the jaws. It is this loss of the periodontal proprioceptors that causes the wavering, uncertain pattern of the "bite" of the edentulous patients. However, if by one trick or the other or, better still, by deliberate training, the patient is taught to move his mandible into the most posterior position that his own muscles can achieve, then suddenly a new and

definite precise pattern of proprioceptive stimuli is established, because now some parts of the capsule of the temporomandibular joints are in an extreme, though unstrained, and, therefore, unique tension.

THE HINGE AXIS AND CENTRIC POSITION

From what was said before, it is clear that this most posterior position that the mandibular musculature of the patient can achieve is the hinge position, and that one way of training the patient, or the patient's muscles, to assume this position, is the determination of the hinge axis. From the moment the patient has pulled the jaws into the hinge position, the capsular proprioceptors, until then only of protective functional value, take over as a guiding principle, and the patient is now able to close precisely and repeatedly into the same "occlusal" position. This automatic behavior is soon reinforced by conscious perception of the stretch of the capsule, provided the patient is, or can be made, "movement conscious."

Once the hinge position had been interpreted as the centric position, the determination of the hinge axis was also made on the patient with a full or partial complement of teeth. The technique of this procedure is well known, and rests on the elimination of tooth contact by the application of a central bearing screw. In other words, during the attempt of determining the hinge axis, the patient is temporarily "edentulous," and his muscles behave exactly as those of an edentulous individual. This means that they have lost the precise guidance in closing, and this movement now is entirely erratic. However, when the patient learns, in one way or another, to move his lower jaw in a pure hinge movement, in other words, when the patient learns to pull his mandible into its most retruded position, then the unique tension of the capsule offers a new set of proprioceptive signals to the wavering musculature, and from this moment on a new and secure closing movement is established which leads the mandible and the registering pin again and again unerringly into the same position. The error was made to explain the replacement of erratic by secure movements as a consequence of having put the condyles into their rightful, namely, "centric" position by eliminating the displacing influence of the occluding teeth. As a matter of fact, valuable as all these observations are for an understanding of the neuromuscular physiology of the human temporomandibular joint, they cannot be used to prove one or the other concept of "centric position."

The proprioceptive neural patterns in the normal automatic and in the learned hinge movements are radically different. During hinge movements, the proprioceptive sensations in the capsule are consciously felt *while* they exert their leading influence during the closing movement if this, at least in its last phase, is a true hinge movement. Thus, the newly learned closing movement is in contrast with that of the average dentulous patient, which is automatic and directed by the engram of periodontal sensations and is felt only at the end of the movement. This point is of great importance because it invalidates many findings on individuals in whom the hinge axis had previously been determined and who, therefore, are conditioned to perform *conscious,* as against *automatic* movements. Experiments on such individuals have led to the belief that the hinge position, i.e., the most

posterior position, of the mandible is a functional position. Such conclusions are, to say the least, open to serious doubt.

The understanding of the neuromuscular mechanism in the edentulous or temporarily "edentulous" patient, however, explains many interesting observations. Only one of those may be mentioned here. During extensive reconstructive work, new inlays and crowns were constructed in the hinge position of a patient. During the treatment the teeth were protected by temporary inlays and crowns, constructed in the patient's natural median occlusal position. Whenever these temporary fillings were replaced by the permanent ones, the patient closed at the first attempt into the new occlusal position, the hinge position. When, however, at the end of an appointment, the temporary fillings and crowns were again inserted, the patient had to search for the occlusal position a few times, until the automatism was reinstituted. In the hinge movement, conscious signals were immediately available, but, in the meantime, the engram of periodontal proprioceptive stimuli had faded out and had to be re-established by letting the oblique planes of the teeth lead the jaw into the correct position.

Where, then, do we stand today in the controversy over the jaw relations in centric position? I think it would be best to reserve judgment and to consider "centric" or "ideal" or "harmonious" mandibular position as the definition of a problem rather than of a solution. Clinically and theoretically, we could be fully satisfied with two factual, well-defined positions: the median occlusal position and the hinge position of the lower jaw.

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A STUDY OF PHYSIOLOGIC REST POSITION AND CENTRIC POSITION BY ELECTROMYOGRAPHY

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THE DETERMINATION OF PHYSIOLOGIC rest position and centric relation of the mandible to the maxillae is of paramount importance in almost all fields of dentistry. Previously, these have been derived from geometric relations. Roentgenographic studies have correlated the position of the condyle in the glenoid fossa to these positions. Measurements have been made with intraoral and extraoral devices and registration materials, but accurate measurements of the neuromuscular mechanism have not been made.

It is apparent that in the definition of physiologic rest position, we speak of a condition of absence of activity of the muscle complex attached to the mandible. The determination of lack of activity is beyond the capacity of human senses; for this reason apparatus which is sensitive enough to meet the task must be employed. The method requiring the fewest assumptions and affording the most convenient study of muscle action is electromyography. With this method activity or lack of activity is measured as change in the electric potential recorded from the muscle.

There are many different methods for determining centric position, and the resultant definitions vary with the method employed. Since it is a functional position, it seemed worth while to investigate the appearance of electromyographic patterns of patients with normal occlusion. It was hoped that the results of these studies would aid in ameliorating the confusion in determining and defining centric position.

Niswonger,[1] Gillis,[2] Tench,[3] Pleasure,[4] Thompson,[5] Boos,[6] Shanahan,[7] Holic,[8] and many others have studied the rest position and centric position of the mandible. In all of their methods, it is evident that a great deal of skill and clinical sensitivity must be employed by the observer to determine these positions, especially in the edentulous patient. The mandible is under the influence of gravity and neuromuscular forces. The interplay between these forces is so great that unless some means is found to stabilize the mandible in its relation to the skull during the period of observation and registration, many errors are possible. Some workers, Thompson in particular, have repeated their readings after time intervals to check on their reproducibility. Reproducibility is a good check on correctness of results if the method of measurement is sensitive enough to detect possible movements which, though small in dimension, may be important physiologically.

Received for publication Dec. 27, 1955.

This article describes the use of the electromyographic method for the determination of physiologic rest position and centric position, and presents some electromyographic records typical of these positions, and of deviations from them.

PRINCIPLES AND METHOD

The muscles attached to the mandible are considered a myotatic unit. According to Szentágothai,[9] this myotatic unit may be defined as consisting of the muscles of the mandible that are mutually dependent, together with their reflex connections, excitatory and inhibitory. The muscles around a joint have the dual function of providing for movement and of maintaining stability in its rest position. The movement produced by muscles which are under voluntary control is a function of the number of motor units which are active at any one time. The action of each motor unit is on an all-or-none basis, and the mode of action of the moving part is determined by the coordinating activity of the nervous system. The number of units active in the synergists and antagonists, and the timing of the contraction and relaxation are under the influence of the proprioceptive system. The reflexes include stretch and reciprocal innervation reflexes.[10]

When a muscle contracts, mechanical energy, heat, and electrical activity are produced. The electrical activity is minute, but it can be measured accurately by the use of proper amplifying apparatus. The amplification must be of the order of 10^5 to 10^7 since the display and recording of bioelectrical potentials is usually performed with insensitive cathode ray tubes or ink writers. Therefore, signals must be kept free from all kinds of electrostatic and electromagnetic interference, particularly that derived from AC mains, DC commutator ripple, diathermy apparatus, etc. In addition, the circuit must be constructed so that there is a low inherent noise level. To lessen the possibility of room sounds being amplified, and audio oscillation being fed back from a loud speaker, if one is coupled to the circuit, the amplifier must have "low microphonicity."

The electrical activity of the muscle is picked up by electrodes and carried to the amplifier. The first or input stage is specially designed to avoid, as far as possible, the introduction of any form of outside interference; the first stages establish the signal to noise ratio. In order to visualize the current fluctuation, the amplified signal is fed to a cathode ray oscilloscope or to an ink writer. Many of the previous electromyographic recordings (Moyers,[11] Pruzansky,[12] Perry,[13] Carlsöö[14]) presented in the dental literature have used ink-writer recordings. The data presented have been definitely helpful in recording and comparing the gross pattern of muscle impulses under varying conditions of activity. However, crystographs and penmotors are not accurate above 100 cycles per second, and they distort the intimate details of wave form which are important in the study of physiologic rest position and centric position.

The absence of inertia in the electron beam of the cathode ray oscilloscope make it the best instrument for visualizing the activity in undistorted fashion. Permanent records of the patterns seen on the face of the cathode ray tube can be made photographically. Recently, a magnetic tape-recording apparatus has been coupled with the circuit. This apparatus has the advantage of playing back sound as well as the picture. The audio sounds are useful in following the visual record.

RECORDING PROCEDURES

A differential high gain amplifier employing resistance-coupled dual triodes and a cathode ray oscillograph were used for our studies.* Recordings were made from the masseter muscles, as the starting point, for taking readings of physiologic rest position and centric position. Lightweight surface electrodes were placed on the skin overlying the masseter muscle. It is important that electrodes are secured properly (movement of electrodes and improper contact produce serious artefacts).

The major factors which influence the electromyographic readings of physiologic rest position and centric position are posture, pain, fatigue, and central nervous system excitation. It is important that noise and other sources of disturbance to the patient be eliminated prior to taking electromyographic readings.

After the electrodes were applied, the patient was asked to contract and relax the muscles. It is important to check at this point to make sure that external interference patterns are not being picked up. Any attempt to study physiologic rest position and centric position in the presence of electrical interference will not give accurate readings.

In our initial studies we had the patient sit in the dental chair in a variety of positions, with and without the backrest. In later work all readings were made with the patient standing erect. The effect of gravity and posture will be discussed later.

A variety of materials were tried as the registering medium for recording centric position and physiologic rest position. In the registration of physiologic rest position in particular, we adopted semifluid materials which were capable of hardening upon a supporting base. Plaster of Paris was also used in a small number of patients.

The patients were asked to watch the electromyographic pattern of the specific position on the oscilloscope and maintain that position constant during the registration period. We will call this system a "visual feed back control."

For study of centric position 215 patients were selected who were judged normal by the following criteria suggested by Alexander[15]: (1) normal movements of the joint in articulation of speech, in mastication of food, and absence of occlusal trauma; (2) no history of temporomandibular joint disturbance; (3) no history of, or indication for, orthodontic treatment; (4) no evidence of periodontal disease.

CENTRIC RELATION

The patients were asked to stand erect and hold their teeth lightly in occlusion. The myogram seen in approximately 85 per cent of the patients is shown in Fig. 1. The amplitude of the waves is between 15 and 20 microvolts, the frequency is between 180 and 220 cycles per second. Included with Fig. 1 is a photograph of the baseline, which may be used for comparison with the other electromyograms

*The amplifier is a single channel Medcraft M1 electromyograph. Signals are recorded on magnetic tape, and are seen on a 5 inch cathode ray oscilloscope. The first stage heaters are fed by a 6 volt storage battery. Sensitivity: 100 microvolts equal 2 inches. A high Q circuit is included to reject power line frequency up to a level of about 70 microvolts in a very narrow band to permit the operation of the instrument in areas of strong electrical fields without the necessity of furnishing a shielded enclosure.

in this article. In the remaining 15 per cent of the patients, neuromuscular relaxants were needed to produce the relatively quiescent electromyogram of the centric position. The combination of Oranixon (mephenesin) and Dormison (methylparafynol) proved most effective in reducing the tensions which interfered with the production of the myogram. The details of the drug study will be reported elsewhere.

The attachment of an extraoral device to the face or merely touching the patient's face, or the introduction of any device or material in the mouth to which pressure can be applied, act to produce high muscular activity as shown on the electromyograph. This activity is large enough to prevent registration of physiologic rest position or centric position (Fig. 2).

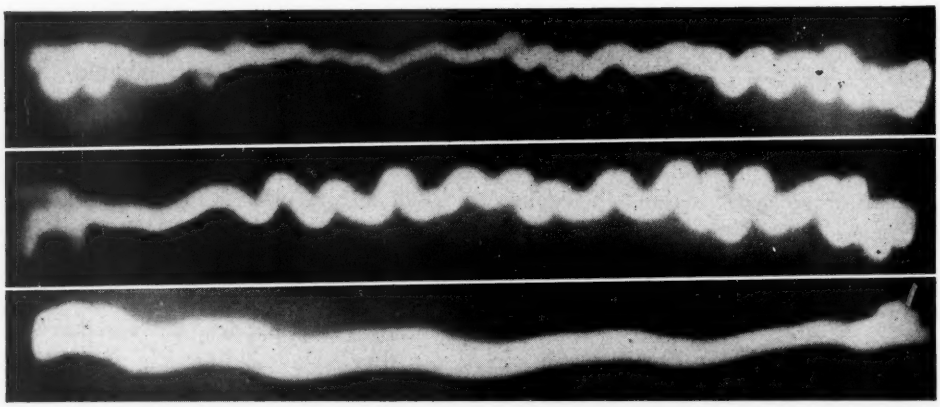

Fig. 1.—Potentials recorded from masseter muscles: *A* and *B*, electromyographic records of centric position; *C*, baseline. (Time = 0.1 sec.)

PHYSIOLOGIC REST POSITION

Registration of physiologic rest position, in the patient with teeth, is easily accomplished by having the patient maintain his jaw in the position which indicates electrical silence on the oscilloscope while the semifluid material (rubber base impression material) sets into a rigid pattern. This material was used in combination with a wax interocclusal record acting as a support for the impression material. The wax record is coated on one side with the impression paste prior to registration. It is important that the teeth do not contact any portion of the wax interocclusal record. If wax is contacted, the pressure effect mentioned previously occurs. It is not possible to register physiologic rest position when the stimulus of pressure or pain is present.

The records of physiologic rest position are shown in Fig. 3. It will be noted, by comparing with Fig. 1, that the number of motor units firing in this condition are practically negligible. This is about the lowest order of activity we have found.

When electrical silence was found in one muscle to indicate physiologic rest position, our tests show that all other muscles of this myotatic unit were also electrically silent. During the determination of the centric position, the muscles

on both sides of the jaw were examined and found to give the same electromyographic patterns.

RECORDING MATERIALS

Plaster of Paris was found to be an unsatisfactory registration material because it acted as an irritant, as evidenced by the lack of ability of many patients to maintain the electromyogram of physiologic rest position during the registration period. When wax was used, failures resulted from two causes: the major difficulty is that pressure must be applied in order to produce a registration; another difficulty is that after pressure has been applied, the teeth may be disengaged from the wax without the operator being aware of it.

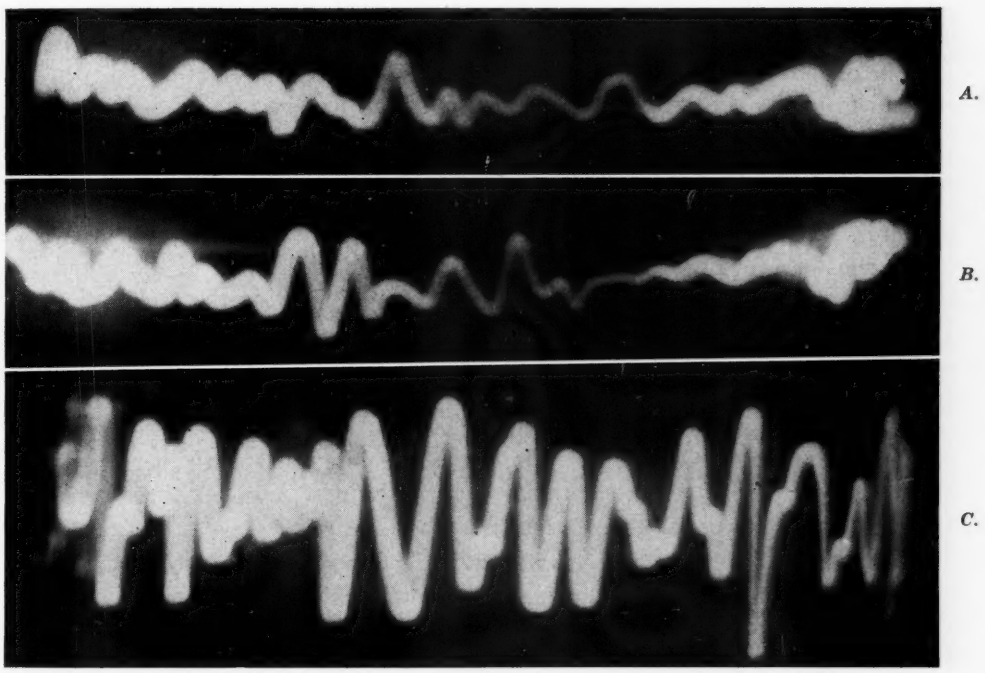

Fig. 2.—Movement from centric position is characterized by increased activity as shown in *A* and *B*; *C* shows the effect of maximum pressure.

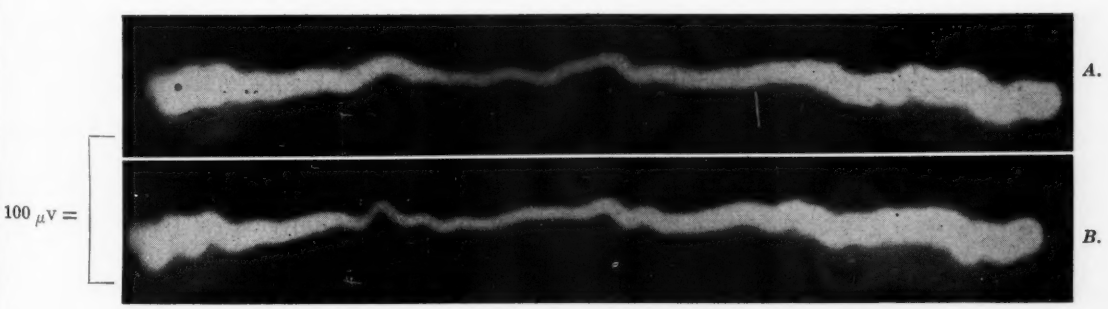

Fig. 3.—Electromyographic records of physiologic rest position. The slight activity present above the baseline can be interpreted as minimal "tonus."

EFFECT OF THE POSITION OF THE HEAD

Physiologic rest position is markedly influenced by the relative position of the head and the body to gravity. When the mandible is suspended in the relaxed position, free of contact with any support, movement of the head produces a shift of the mandible (see Fig. 2). The same situation exists in the edentulous patient during the determination of centric position. Satisfactory readings of physiologic rest position and centric position may be obtained when the patient is seated erect in the dental chair, without back support. However, when support is given to the back, the patient has a tendency to slump, thus throwing off the postural relations of the mandible, the skull, and the body. We believe that the most accurate condition for recording centric position and physiologic rest position exists when the patient is standing erect.

The registration of centric position and physiologic rest position in the edentulous patient makes use of the same method of visual feed-back control during the registration period, with the following modifications: The rubber impression paste is applied to occlusion rims which have been previously trimmed to eliminate overextension or impingement on tender areas. We have observed that unless all sources of pain are eliminated, correct readings cannot be obtained. The occlusion rims are cut down to allow space for several millimeters of the semifluid rubber impression material to be present interocclusally during the registration of either physiologic rest position or centric position. Once the occlusion rims have been adjusted and coated with impression material, the patient produces the electromyogram characteristic for the position, and maintains it during the registration period. These readings can be reproduced by the patient several weeks or even months later when the same registration matrix is inserted. A further check on this method is possible when teeth are set up on the baseplates for the try-in and for the completed dentures.

The method described has been used in patients who have lost tooth substance due to attrition and in patients who have lost a sufficient number of posterior teeth to disturb normal centric position. The data derived from these studies have been of use in the clinical rehabilitation of the occlusal relations.

DISCUSSION

Physiologic rest position and centric position are essentially postural and physiologic relations. The use of the electromyographic technique described establishes the physiologic relations of the mandible to related parts easily, and allows quantitative, roentgenographic, and anatomic studies.

In our function as dentists, it is our objective to restore balanced postural relations and thus make possible the maximum function with the minimum expenditure of energy. The method of establishing centric position and physiologic rest position by the electromyographic technique satisfies the criteria of physiologic balance as found in normal patients.

Thompson[5] has reported that "not only does the mandible return to its resting position but it invariably establishes a normal free-way space as well." The

free-way space (interocclusal distance) can be defined as the space traversed when the mandible moves from physiologic rest position to centric position.

If physiologic rest position is encroached upon by increasing the vertical dimension of occlusion, a constant bombardment of impulses is generated in the powerful muscles of mastication, in a tendency to restore the physiologic rest position. Unfortunately, teeth and supporting structures are often injured, and habits of clenching and grinding teeth are generated. These forces are more manifest when the patient sleeps because the restraining forces of gravity and conscious control are absent.

Jankelson,[16] has indicated the relation of centric position to swallowing. We have observed that movement from rest position to centric position is usually accompanied unconsciously by the swallowing of saliva. It is suggested that the mechanism of restoration of the interocclusal distance and centric position in cases of jaw malposture (bite opening), appears to be influenced by the neuromuscular reflex of swallowing saliva.

We believe that the great variety of methods of registering physiologic rest position and centric position should be evaluated by the electromyographic technique. The data derived from such studies would aid in the elimination of the harmful effects so often associated with mandibular malposture.

During the period of development from the infant to the adult, great variation occurs in the dimension and configurations of the bone, the distribution of mass in the various parts, and in the degree of movement in the joint. These transformations are not under voluntary control, and are passive elements of the motor mechanism. The active element of the motor mechanism is the neuromuscular complex which is susceptible to voluntary control. With the establishment of reference points (physiologic rest position and centric position), a more precise study can be made of the relation between structure and function.

SUMMARY AND CONCLUSIONS

1. A single channel high gain differential electromyograph operating in an unshielded room can be used to determine physiologic rest position and centric position.

2. Centric position has been found in 215 normal adults to produce a characteristic electromyogram.

3. The registration of centric position in edentulous patients and others requiring mandible repositioning is accomplished by the technique of visual feed-back control. This method allows the patient to place his mandible at the specific position and maintain it during registration by watching the electromyographic patterns.

4. Physiologic rest position is registered in the same manner while the patient watches and maintains the pattern of electrical silence in the electromyogram.

5. Examination of other muscles of the masticatory mechanism indicates that when one muscle of the myotatic unit is at physiologic rest, the others are also silent.

6. The great variety of methods of registering physiologic rest position and centric position should be studied and compared by the electromyographic technique.

We wish to thank Dr. Harry Grundfest, of the College of Physicians and Surgeons, Columbia University, for his kindness in advising us on the proper methods for pursuing this study and for reviewing this paper.

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TISSUE CONSIDERATIONS IN COMPLETE DENTURE PROCEDURES

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THE MASTICATORY ORGAN WILL function whether natural or artificial teeth are present or absent, even though the efficiency of the function is lessened by the absence of teeth. Natural teeth can be, and often are, inharmonious with the function of the masticatory organ, but complete denture restorations *must conform* with the functions of the tissues of the organ if the restorations are to be used successfully. The cardinal considerations in all complete denture methods must deal with the tissues, and the natural function of these tissues must be held inviolate.

METHODS AND INFLUENCES IN CENTRIC REGISTRATION

Wright[1] has called our attention to the influence of the tongue upon the retention of the lower denture. It was pointed out that the size, the position, and the habits of the tongue exert a tremendous influence upon the retention of the denture. These are premises to which any serious student of complete denture prosthesis heartily subscribes. A sudden loss of retention of the lower denture can be observed when the tongue is retracted toward the throat. This tongue form and activity is a basic physiologic function for which proper allowances must be made in the impression procedure. In the registering of centric relation, these basic biologic aspects of tongue form and function are often put aside, and considered only as being applicable to impression making. If the tongue is crowded posteriorly by the bulky central bearing point mechanism, it is forced to assume a strained and unnatural position while the most important single record for successful denture construction is made.

The extrinsic muscles of the tongue are closely allied in function with the suprahyoid group of muscles. The suprahyoid group of muscles and the masticatory group of muscles act as antagonists to each other in function, although both groups act together also as antagonists to the deep cervical group of muscles.[2] Any abnormal influence upon one muscle group is reflected upon the function of the other group. When the tongue is forced to retract behind its normal position by the central bearing point mechanism, the hyoid bone is depressed. When the hyoid bone is depressed, the suprahyoid group of muscles will tense. If the suprahyoid muscles are not relaxed, their antagonists, the masticatory muscles, cannot relax. With the tongue displaced posteriorly, the reflex action of the

Read before the Missouri State Dental Association, May 7, 1956.
Received for publication Dec. 20, 1955.

masticatory muscles could be influenced sufficiently that the position of the mandible would not be recorded in centric relation.

The health of the patient, the tonicity and strength of the muscles of mastication, and the condition of the residual ridge tissues should be the guides in the selection of the technical procedures for registering centric relation. The patient who is in poor health has lost strength in these muscles. The problem is made more complex when complicated mechanical devices are used for determining centric relation. When these tissue difficulties exist, the simplest methods of making centric relation records are indicated. The method should be one which produces an equalized distribution of maxillomandibular stress under a minimum of pressure. By employing a method of centric registration which meets these requirements, a maximum occlusal contact occurs in centric relation, before the stronger maxillomandibular stresses, with their resultant tissue displacement under the denture bases, are applied (Figs. 1, 2, 3, and 4).

Fig. 1.—The indexed occlusal surface of the upper hard wax occlusion rim.

METHODS AND INFLUENCES IN PROTRUSIVE AND LATERAL REGISTRATIONS

The accuracy of protrusive registrations has been questioned. Owen[3] maintained that this registration could approach accuracy only if the upper and lower anterior teeth had been set upon accurate denture bases, and if the protrusive relationship was recorded with the anterior teeth in an edge-to-edge relation. Both he and Stansbery[5] pointed out the need for a protrusive movement of at least 6 mm. from centric position for it to influence the articulator settings.

There may be some doubt as to the accuracy of any method of registering protrusive and lateral positions. It is assumed that these registrations, when transferred to the articulator, represent the degree of the inclination of the downward and forward movement of the condyles in translatory movements. The records obtained by these registrations are directly influenced by several factors.

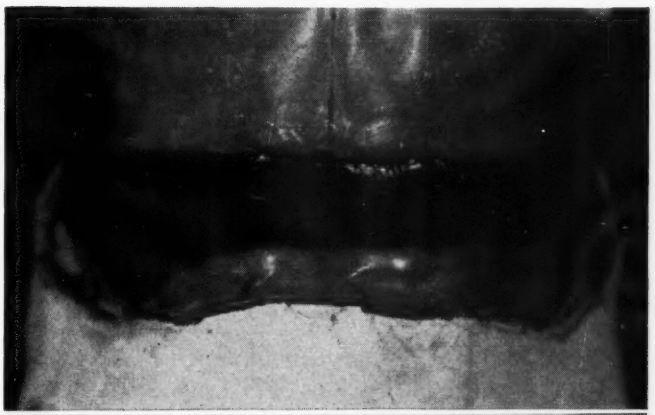

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 2.—The primary registration of centric relation with a roll of softened wax on the lower baseplate. Protrusive and lateral mandibular movements are made from rest position to determine whether the mandible closes with wax record fitting into the indices on upper occlusion rim.

Fig. 3.—Continuous vertical markings are cut from the top of upper occlusion rim to the lower border of lower occlusion rim.

Fig. 4.—The lower occlusion rim is reduced in height, and a thin mix of regular set plaster of Paris is placed on it. Closure is made until the vertical markings are in line.

These are: the displacement of the ridge tissue, the condition and strength of the muscles of mastication, the consistency of the material being used to make the registration, the method employed in making the registration, and the distance the mandible is required to move from centric position to the position being recorded. If wax is employed in making the record, a moderate amount of maxillo-mandibular pressure is necessary to make the registration. This pressure is usually sufficient to displace ridge tissues if they are not firm. If the chew-in method is used, an even greater pressure will be required to make the registration. I have observed that the greater the pressure used in the registration, the steeper the condylar guidance reading obtained.

It seems to be inconsistent to use a minimum amount of pressure in making the impressions, and then use a greater amount of pressure in recording the centric, protrusive, and lateral relations.

Two questions arise in regard to the protrusive and lateral registrations. Is a constant angulation of the translatory movement of the condyle actually being measured? My clinical observations indicate that the degree of condylar inclination is directly proportionate to the amount of pressure employed in making the registration. The displacement of the ridge tissues and the consistency of the material being used to make the record can influence the results of the registration, and may therefore introduce errors which must be held to a minimum. Do we not record a definite functional pattern for the individual which is correct on that day and in that particular situation, but one which may not be repeated for the same patient on another day?

THE RELATION OF TISSUE CONDITIONS TO THE IMPRESSION METHODS

DeVan[4] has emphasized that the objective in partial denture construction is preservation of the health of the tissues while restoring lost functions. This is a principle that should be applied also in complete denture construction. The consistency of the tissues of the basal seat area should determine the technical approach in the making of the impressions. An impression method and materials which suit the requirements of each individual mouth should be selected and applied. There seems to be but one premise that is constant to all open-mouth techniques. A minimum of pressure should be applied in making the impressions if preservation of tissues is the main objective. An evaluation of the condition of the tissues involved, and the employment of a technique that will provide considerations for these tissues, will greatly enhance the chances for successful denture service.

When a patient has suffered the complete loss of the alveolar process, the mandible presents a ridge of dense bone labial and buccal to the former site of the alveolar ridge. Anteriorly, the genial tubercles are prominent and high above the residual ridge on the lingual side, and, posteriorly, the mylohyoid ridge is sharp and prominent. The external oblique line is prominent on the buccal side of the residual ridge None of these landmarks of osseous structure are on the alveolar process but they are on the basal part of the body of the mandible.

Resorption of bone can be caused by undue pressure on the overlying soft tissue structure.[5] If the soft tissues are deprived of adequate nourishment due

to compression, the underlying bony support resorbs sufficiently to permit adequate nourishment to return to these soft tissues. When the delicate balance between cellular volume and vascular volume in the soft tissues is disturbed, the underlying bone structure resorbs sufficiently to restore that balance. From these observations, it is reasonable to assume that those impressions that are extended to the physiologic and biologic limits over the basal bone area will result in dentures under which less alveolar process resorption will occur. It is apparent, clinically, that resorption of basal bone seems to proceed more slowly than resorption of alveolar process.

THE PALATAL RELIEF AREA

The use of the palatal relief in upper dentures has been based on the belief that the median raphe, overlaid with a thin layer of mucous membrane and periosteum, should not be a primary stress-bearing area. This follows the premise that the alveolar ridges should receive the primary stresses of the denture, and when resorption of the ridges does take place, the median raphe should not become an area resistant to forces applied to the denture.

It would seem more logical to omit the palatal relief and to permit the basal bone of the palate to receive its share of the stresses. Since resorption of basal bone proceeds more slowly, some of the stresses upon the alveolar process would be lessened. Also, in many mouths, a proliferation of epithelial tissue occurs in the area of the palatal relief. This hyperplasia can be effectively treated and made to disappear, if the relief area in the denture is filled so the entire palate has an even contact with the denture base.

SELECTION OF TEETH

The work of Williams, House, Fisher, and Frush, and others has given us some semblance of order in the selection and arrangement of the anterior teeth. The use of pre-extraction photographs and casts permits us to comply with the cosmetic demands of each patient. One of the purposes of the trial wax setup is to determine how closely we have approached esthetic harmony. However, the esthetic qualities of the anterior tooth arrangement are often lost when the teeth are balanced in protrusive relation before the finished dentures are inserted. In many cases, a choice must be made between occlusal harmony in protrusive relation and esthetic harmony in centric relation.

Much remains to be done toward the establishment of rules for the selection of posterior tooth forms. For many years it has been believed that the angle of the cusps of the posterior teeth should conform as closely as possible to the angle of inclination of the condyles indicated by the protrusive record, and that the occlusal forms of the posterior teeth should conform closely to the occlusal forms of natural teeth. The natural posterior tooth can afford its steep inclined planes and sharp cusps, since each tooth is firmly supported by alveolar bone; but the artificial posterior tooth must function on a base which is slightly movable regardless of the amount of retention and stability it possesses.

Movement of the soft tissues of the basal seat area and the resiliency of the tissues under occlusal stress preclude the possibility of ever obtaining perfect

stability. Therefore, the natural posterior tooth occlusal form, which functions so efficiently when its roots are encased in bone, would offer resistance when it is used on a slightly movable base. It does not seem reasonable to assume that an elderly patient, with loss of tissue tone and loss of masticatory muscle strength can use efficiently a posterior tooth whose occlusal form is at an optimum of efficiency only when it functions on a fixed base. If preservation of tissues is to be one of the main objectives, it might be better to use a tooth with a flat occlusal surface set on a flat occlusal plane, or a low cusp acrylic resin tooth set to a moderate compensating curve in a mouth that has poor tissue tone and lack of muscle strength.

The nature and health of the tissues, their ability to function, and the preservation of these tissues should be our guiding precepts in the selection of the posterior tooth form. If a mouth has well-rounded ridges that are parallel to each other when the mandible is in centric relation, and the masticatory muscles are at an optimum of functional efficiency, then the use of the cusp tooth may be indicated. If the ridges are not parallel when the mandible is in centric relation, and there has been loss of alveolar process with resulting flabbiness of ridge tissues, then a posterior tooth form should be used that will not further complicate an already difficult situation.

CORRECTION OF OCCLUSAL DISHARMONY DUE TO TISSUE CHANGES

After the dentures have been worn for a brief period of time, some changes usually take place in the tissues of the basal seat area. Some compensation must be made for these tissue changes, since they will influence the occlusion of the teeth. Many of the discomforts associated with denture wearing are directly attributable to occlusal disharmony. Therefore, it becomes necessary to adjust the occlusion frequently if the dentures are to be worn with comfort and with the least possible damage to the supporting structures.

SIGNIFICANCE OF THE INHERENT FUNCTION OF THE MASTICATORY ORGAN

Man is born into this world edentulous, with an inherent opening and closing movement. The masticatory organ is a functioning organ at birth, as is evidenced by the child's ability to nurse, even though no teeth are present. The teeth are added later in life as an auxiliary and lesser part of the organ. As Moyers[6] has shown, abnormalities in the occlusal relationship of these teeth produce an abnormal influence upon various segments of the temporalis muscles, an influence that remains for some time after the removal of the teeth.

I have made several sets of dentures for a patient with complete anodontia. The first dentures were made when the child was 9 years old. The patient is now 17 years old, and I have made complete dentures for him each year. With Moyers' research in mind for substantiation of my clinical observations, I can report that no difficulties were encountered in the registration of centric relation, and that it was found on the patient's true and relaxed closing axis. The muscles had never been exposed to any abnormal natural tooth contacts in occlusion. Both 20 degree and anatomic teeth have been used for this patient with no appreciable difference either in function or comfort.

In view of these observations, I suggest that a patient who is wearing properly made complete dentures becomes a successful user of those restorations when he reverts to that true and inherent opening and closing movement of the mandible that was present in infancy before the natural teeth became a part of the masticatory organ. In recording centric relation, and in learning to wear dentures, the old phrase of "close, suck, and swallow" (as demonstrated by the nursing infant) cannot be overlooked.

PATIENT EDUCATION

Many patients who seek complete denture service have the illusion that, once the dentures are placed in the mouth, all of their dental troubles are over. The patients should be told that the dentures being placed in their mouths are permanent, but that the tissues upon which these dentures are placed are not permanent and that there are constant natural physiologic changes of building up and tearing down within these tissues, and that under the constriction of the denture base, the building up never quite approximates the tearing down.

Patients ask about the care of the dentures, but seldom is any awareness shown for the care of the tissues upon which these dentures are placed. It is our responsibility, therefore, to teach the patient the importance of home care of the denture-supporting tissues. Dentures should probably never be worn after retiring at night. It is just as necessary for the denture-bearing tissues to recover from fatigue as it is for the other tissues of the body. Instruction in home care of the tissues is even more important for the edentulous patient than for the patient with a natural dentition. For, after the loss of the natural teeth, complete dentures are the last resort, and these restorations can be no better than the foundations upon which they are placed. Massage of the denture-bearing tissues with a soft brush, or with gauze wrapped around the finger and flavored with some dentifrice, should be done at least once every twenty-four hours. If Stansbery's[5] observations can be accepted, massage and stimulation of blood circulation will help to prevent bony resorption, and better preserve the health of the remaining tissues.

SUMMARY

The condition of the tissues should determine the choice of the technical approach to the construction of complete dentures. The materials and the methods must be adapted to the characteristics of the tissues, for the tissues cannot adapt to techniques or materials. It must be borne in mind that a portion of the tissue of the basal seat area is repair tissue, and that as repair tissue, it receives less blood supply than the original tissue. The more questionable the health of the tissue, the less complicated our techniques should be. There is no material or method that can be classified as the panacea for the dental ills of all denture patients. There are occasional problem patients whose prosthodontic treatment is doomed to failure in spite of the most exacting methods of denture fabrication employed. In some of these cases, it is well to recognize that successful treatment may be beyond the capabilities of the best prosthodontists. A patient

in menopause, with a thin, glossy, almost transparent mucous membrane, should be referred to the endocrinologist or internist for treatment before dentures are made. Endocrine disturbances at this period in life are often reflected in the condition of the oral tissues. The systemic disturbances of untreated diabetes and of anemia will often preclude the possibilities of consummating a successful denture service unless treatment for these disorders precedes the course of dental treatment.

CONCLUSION

The use of complicated technical procedures may ignore completely the need for an adequate diagnosis and an understanding of human biology. Our knowledge of the histology, the anatomy, and the physiology of the entire masticatory organ should be used, and, from this information, a resolution to employ the simplest techniques that are consistent with accuracy can be made, in order that only those procedures which tend to preserve the health of the tissues while restoring lost function will be employed in the construction of dentures.

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BIOLOGIC PRINCIPLES IN CORRECTION OF OCCLUSAL DISHARMONIES

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IT IS WELL KNOWN what pathologic tissue changes occur in the periodontium, when forces in excess of the physiologic tolerance of the tissues are exerted upon the teeth.[1-3] Experimental,[3,4] as well as incidental findings have shown that these tissue changes in the periodontium occur on both the tension and pressure sides. These tissue changes are known under the term "traumatism"—a morbid condition of tissues produced by mechanical trauma such as: damage to the collagenous fiber bundles on the tension side due to stress beyond the limit of their tensile strength; hemorrhage, thrombosis; necrosis of tissues on the side of pressure. All these changes lead to resorption of bone and later to complete repair and regeneration without an accompanying inflammatory reaction.[4]

These traumatic tissue changes occur in the periodontium, between the alveolar bone and cementum, and have no direct effect upon the tissue of the gingivae.[1-3] It has been postulated, after experimental findings, that if trauma occurs and inflammation is present at the same time, the inflammatory reaction might extend into the tissues damaged by trauma.[9] No other acceptable scientific evidence has been presented to indicate that traumatic occlusion is responsible for pathologic changes other than "traumatism."

These facts do not imply that occlusal forces have no influence upon the structures of the periodontium. We have to consider structure and function as interdependent factors in tissue health—one cannot be without the other. There is a beautiful functional corelationship between the tooth, alveolar bone, periodontal membrane and the fibrous as well as the epithelial attachment of the gingivae. The very delicate mechanism of tissue reaction to changes in function can be very effectively demonstrated by the structures of the periodontium. In a horizontal section, we can easily differentiate the mesial from the distal surface of a root. Fig. 1,*A* shows the distal surface, and Fig. 1,*B*, the mesial surface, of the same tooth. The distal surface is characterized by the fibers of the periodontal membrane extending into the bone, forming what is known as "bundle bone."[10] This is bone which is laid down layer by layer as the tooth moves mesially, embedding fibers on the way. This movement of the tooth is known as the physiologic mesial

Read before the Ninth Annual Seminar of the Colorado Dental Foundation, Colorado Springs, Colo., June 30, 1955.

Received for publication Feb. 27, 1956.

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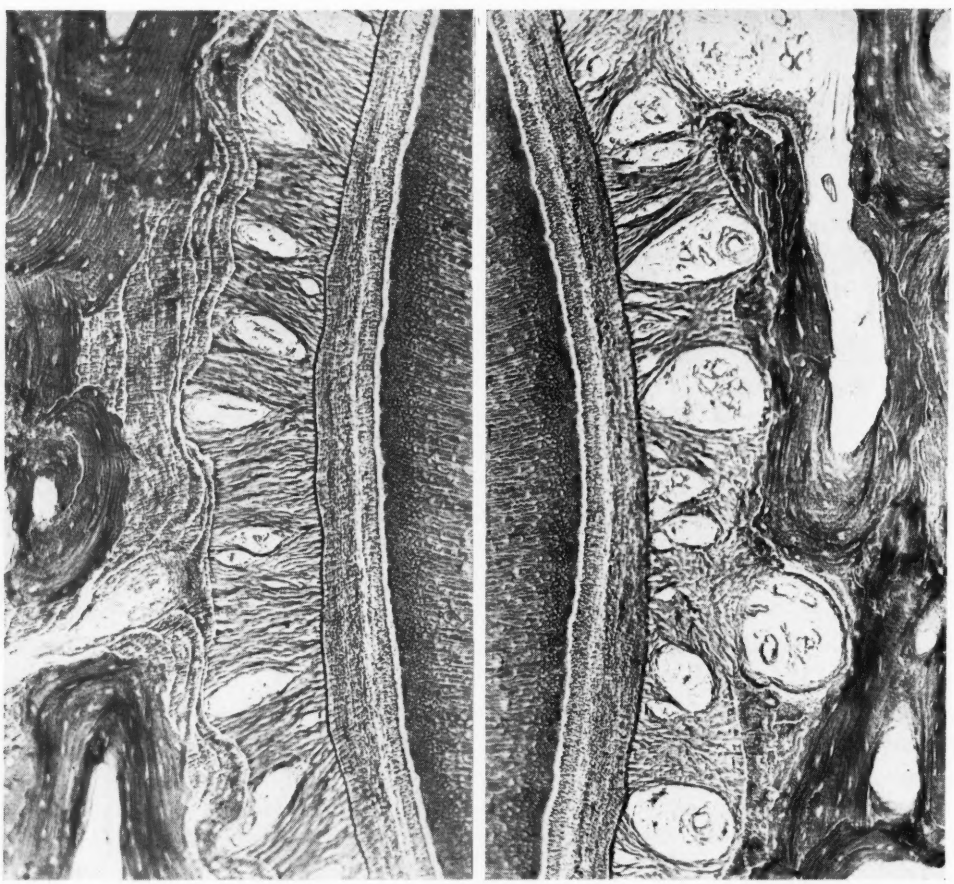
migration of the tooth. Black[11] had observed that the dental arch becomes shorter with advancing age. This is due to attrition of the contact points to contact planes, while all the teeth still remain in contact. According to Black,[11] the loss of tooth substance and mesial shift is equal to about 1 cm. from the mesial surface of third molar to third molar by the age of 40, and increasing with age. Within a lifetime of an individual, this is a very slow movement. Nevertheless, the surrounding periodontium reacts to this minimal change in function with characteristic tissue changes. One of these tissue changes is the development of bundle bone on the side from which the tooth moves. Another tissue change



A. *B.*

Fig. 1.—*A*, The distal surface of the root of a lower bicuspid. The periodontal membrane fibers are stretched; the spaces for blood vessels and nerve fibers are oval; the bone is bundle bone. Sharpey's fibers enter the bone which is laid down layer by layer, embedding the periodontal membrane fibers. The bundle bone is resorbed from the marrow spaces and is replaced by lamellated bone. *B*, The mesial surface of the root of the same tooth. The periodontal membrane fibers are rather loosely arranged; the blood vessel spaces are round. The bone consists mainly of lamellated bone which, in areas, shows shallow resorption lacunae. In small areas, a thin layer of bundle bone can be observed, due to the "see-saw" manner of tooth movement. (From Orban, Balint: Oral Histology and Embryology, ed. 3, St. Louis, 1953, The C. V. Mosby Company, Fig. 149.)

characteristic of this functional stimulus is the tension of the principal fibers and the oval shape of interfibrillar spaces, carrying the capillaries and nerve fibers, surrounded by loose connective tissue. On the mesial side of the root (Fig. 1,*B*) the bone consists mainly of lamellated bone which, on the side of the periodontal membrane, shows shallow lacunae as a sign of resorption. The resorption process was inactive at the time of death. Therefore, we see no osteoclasts present. In some small areas, there is a thin layer of bundle bone present, as an indication that the tooth movement is not continuous, but goes in a "see-saw" manner. The principal fibers are not as taut as on the distal surface, and the interfibrillar capillary spaces are rather round. It also can be considered a tissue adaptation to functional influences that, distal to the bundle bone, resorption has removed part of the bundle bone, and this has been replaced by lamellated bone.

This difference in structure on the mesial and distal surfaces of the same tooth is a very striking example of the acuteness of tissue reaction to functional stimuli.

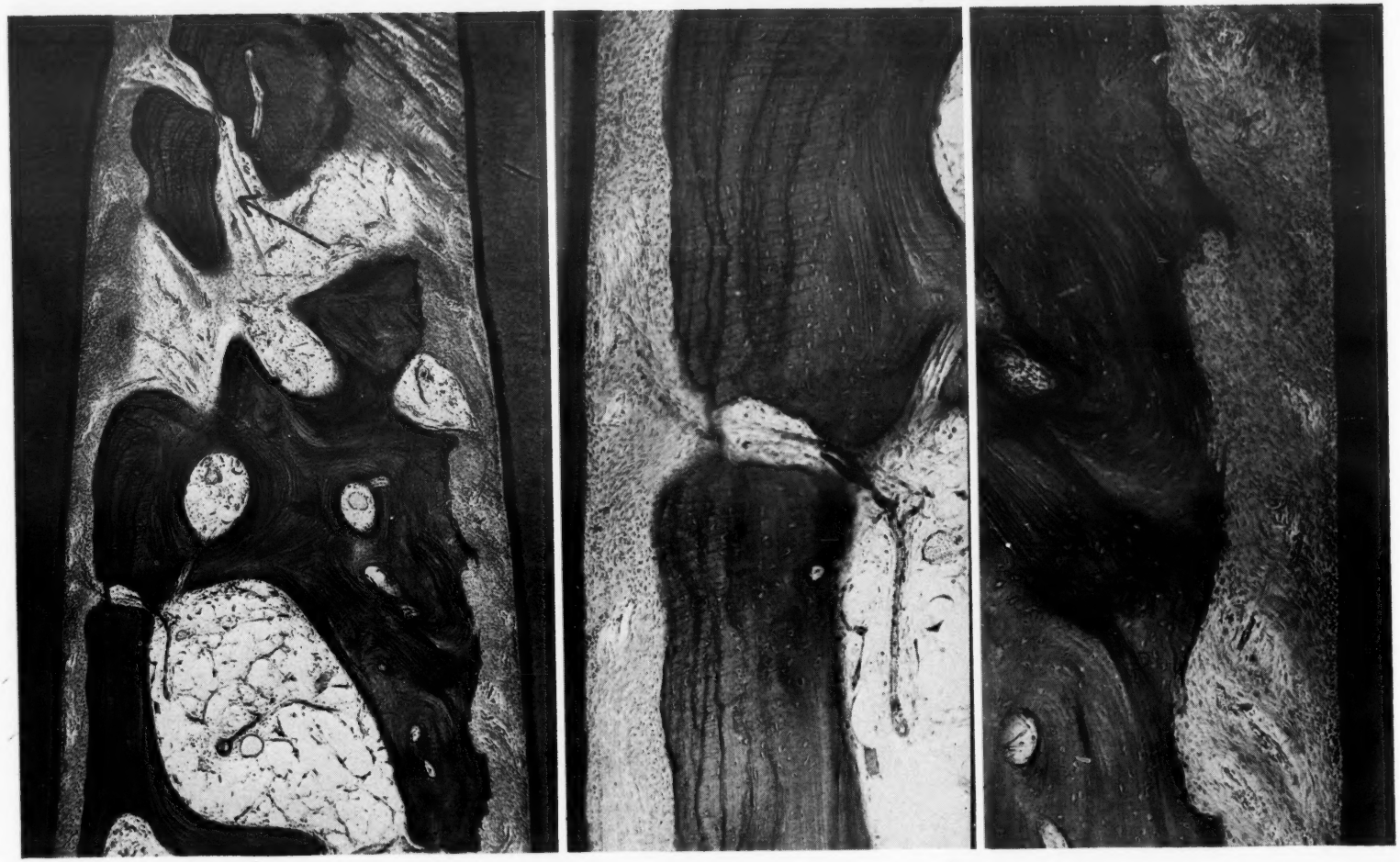
An alveolar septum in the same interdental space shows a different structure on the mesial and distal surfaces, as seen between two lower bicuspids in Fig. 2. The movement of the two teeth is reflected in the alveolar septum, and shows not only a mesial, but also an occlusal, direction of movement. The mesial surface of the septum (distal surface of the first bicuspid) shows the bundle bone laid down layer by layer, and the Sharpey's fibers embedded into this bone. The bone lamellae also indicate that the teeth were moving not straight forward, but also occlusally. The distal surface of the septum (the mesial surface of the second bicuspid) shows resorption lacunae in lamellated bone, as an indication of slight pressure in this direction and mesial migration of the tooth.

It is a well-known fact that the entire periodontium and the jaw bones change, due to diminishing function—disuse atrophy (osteoporosis)—and show just the reverse reaction to increase in functional demands (osteosclerosis).[3,12]

The teeth are not fixed in the jaw in an immobile state. They are suspended in their sockets by a fibrous ligament, permitting a slight mobility in the axial as well as lateral directions. The teeth are not only continuously exposed to the forces of occlusion, which leads to some degree of wear and tear, but they also move occlusally and mesially in their physiologic movements, which is compensated for by occlusal and interproximal attrition. All these movements of the teeth are accompanied by tissue changes.

It has to be understood that all living tissues and organs have a relatively wide range of adaptability to changing functional requirements. Variations in the functional requirements are met by structural changes within the range of adaptability. Disturbances in this equilibrium can occur if the functional demands (extrinsic factors) are beyond the tissue tolerance and adaptability, or if the tissue tolerance and adaptability are lower than the "normal" range (intrinsic factors).

This mechanism of the physiologic tissue changes, regulated by the extrinsic and intrinsic factors, has to be kept in mind when we approach the problem of occlusion. This biologic understanding should be correlated with the mechanical principles in question.



A. *B.* *C.*

Fig. 2.—*A*, An interdental alveolar septum between two lower bicuspids. The direction of tooth movement is indicated by the arrow, and is shown by the direction of the formation of the bundle bone as it is laid down layer by layer. *B*, The mesial surface of an alveolar septum (distal of tooth) with many layers of bundle bone. *C*, The distal surface of an alveolar septum (mesial of tooth) with resorption lacunae in the lamellated bone. (From Orban, Balint: Dental Histology and Embryology, Chicago, 1928, Rogers Printing Co., Figs. 144, 145, 146.)

CONCLUSION

1. The structures of the supporting tissues of the teeth are fully adapted to their function. The better the functional relation between the mandibular and maxillary teeth in every possible position, the more favorable is the strain on the supporting tissues. Such a relation eliminates an extrinsic aggravating factor in the mechanism of functional adaptation.

2. A harmonious relationship between the teeth and between teeth on one side, and the temporomandibular joint and the muscles on the other, assures optimal function and optimal maintenance of the supporting tissues.

3. Though, under normal conditions, the range of adaptability of living tissues is wide, it can be severely curtailed by intrinsic as well as extrinsic factors. It must be the aim of good dentistry to create optimal functional conditions in order to give to the supporting dental tissues the optimal chance of maintenance or recovery under pathologic conditions.

4. Elimination of all known factors impairing the adaptability of the supporting tissues makes use of local periodontal treatment; improvement of dietary regime; elimination of systemic factors; elimination of occlusal imbalance by grinding; occlusal reconstruction; splinting; or a combination of all these and possibly other procedures.

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of tooth) with many layers of bundle bone. C, The distal surface of an alveolar septum (mesial of tooth) with many layers of bundle bone. (From Orban, Balint: Dental Histology and Embryology, Chicago, 1928, Rogers Printing Co., Figs. 144, 145, 146.)

SOME IMPORTANT FACTORS IN COMPLETE DENTURE OCCLUSION

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THE PURPOSES OF THIS article are to add further to knowledge needed for the solution and understanding of our occlusal problems, and to attempt to explain some of the discrepancies in theory and results obtained by the wide variety of techniques now popular in prosthodontics.

This essay is not an exhaustive treatise of each facet of the occlusal problem, but rather one directed toward what appears to me to be new: useful ideas which have arisen from my work with, and interest in, the temporomandibular joint.

In a discussion of this subject, there will be an overlapping of the natural occlusal problem with the artificial occlusal problem because the neuromuscular apparatus initiating closure is identical. Therefore, there will also be some reference to the natural occlusion.

I shall present a method of determining the anteroposterior position of the complete dental arches, as well as the lateral width at the important region of the second molars; this in accordance with the physiology and structure of these parts as I have found them.

I shall present additional in vivo evidence of the function of the external pterygoid muscle; challenge some of the present-day concepts of the action of the temporalis muscle; describe what I consider to be the primary attachment and articulating elements of the mandible with the skull.

Occlusion is a word derived from the Latin infinitive "occludere" meaning "to close." It has developed in dentistry as a two-phased subject—one area involved with teeth, arches, and intercuspal relations; in complete dentures, the mechanics of tooth arrangement; the other area, the forces which produce closure and the various postural relations of the dental arches. This area is involved with inheritance, growth, form, habit, voluntary muscular effort, the neurologic system, sensation and tissue sensibilities; and, in complete dentures, the adult neuromuscular skeletal system. It is also concerned with the physiology of the resting and moving mandible, with mastication, speech, swallowing, yawning, and the action of the mimetic muscle curtain.

ARCH POSITION

The importance of properly placing teeth in a complete denture cannot be overemphasized. This is a major factor which, when properly handled, will con-

Read before the Greater New York Academy of Prosthodontics, New York, N. Y., Dec. 3, 1955.
Received for publication Dec. 19, 1955.

tribute greatly in placing the teeth of an artificial denture within a patient's particular psychologic area of acceptance. Most agree that the sooner a patient becomes unaware of the presence of artificial teeth, the sooner and the more efficiently will function be established. In a review of the literature describing the placing of artificial teeth, it is clear that all are empiric, based entirely on the experience of the operator. It becomes clear that a technique such as this discussion will include would fill a real need in advancing the accuracy of our prosthetic restorative methods. The constant pursuit of the best mechanical leverage does result in many errors.

It is well known that due to the irregular loss of teeth, the mandible is reduced in size. If the loss of molars occurs only on one side, this condition lasting for many years, then the mandible is usually shorter on that side. I have never seen nor heard anyone take this into consideration in developing an artificial arch. An accurate technique for establishing the anteroposterior position of the dental arch based on the mandibular structure of the patient should reveal this fact when present.

Great care is being exercised in establishing adequate jaw relations. The literature is filled with exhaustive discussions of incisal guidance, cusp height, compensating curves, etc. Yet, what could be more important in correlating a complete denture arch to these recordings than to know where to place the anteroposterior position of the very arch which must perform in harmony with the masticatory muscle mass? There is a correct pattern for the arch position of each patient, which, when developed, will contribute to the maximum acceptance and function for that patient.

Further, a technique for establishing the correct position for the dental arch must include a means for recording variations in the width of the structure of the body of the mandible and the related width of the dental arch. Asymmetry is frequently present, which is caused by many factors, such as inheritance, function, bone disease, etc. It is very important that these variations be recorded in such a manner as to enable the operator to set artificial teeth in harmony with them.

Such a method allows for the proper size and location of the space occupied by the tongue, which is an organ that must function in a space to which it is accustomed, an organ which must repose in comfort or else develop many destructive purposeful habits.

ESTABLISHING ARCH POSITION

When posterior teeth are present, I build a temporary splint replacing the posterior teeth and using the existing molars as a guide. The use of such a device will retain the following important records: the anteroposterior position of the dental arch, the width and the height of the arch, and some evidence of the compensating curve.

Such a temporary splint will also retain a record of the tooth bulk. It is an error to offer an inadequate tooth table upon which the patient must try to masticate. Too, the width of the molar crowns provides the connecting link between tongue and cheek; it must be ample and approach the size of the natural

tooth to be acceptable to the sensibilities of the patient. A useful objective is to provide an artificial apparatus that will require the minimum number of muscle movements to accomplish all functions. When the table of the tooth is not broad enough to retain particles of the food bolus comfortably, it requires a greater number of movements, especially of the tongue, to retrieve these particles and to keep replacing them back over the teeth in order to continue mastication. Also related to tooth bulk is the impossibility of developing the proper anteroposterior arch relation with undersize or oversize tooth forms.

The basic physiologic and structural evidence which I use in establishing arch position became apparent in my studies of the muscles which move the mandible. These studies were made first on cadavers and then on living patients. One fact of great importance to the construction of successful complete and free-end partial dentures was noted in both types of studies. It is also of importance to every dental specialty. *The natural dental arch, from the distal surface of the second lower molar forward, is anterior to all of the powerful elevator muscles of the mandible.* Further, it was found in several hundred patients with normal mandibles *that the anterior border of the masseter muscle was consistently immediately distal to the mandibular second molar during contraction.*

The recognition of these facts is very important in that: (1) it offers a physiologically correct and useful place from which to project the anteroposterior location of the artificial dental arch; (2) it relates the arch correctly to the customary application of force by the "masticatory muscles," thus lessening the posterior fulcrum action during isometric contractions at tooth level, and decreasing the tilting force during isometric manipulations. These observations indicate that the most important single tooth placed on an artificial complete or free-end partial denture is the mandibular second molar.

The small measuring device (Figs. 1 and 2), upon which the patient exerts gentle isometric contraction, will enable the operator to palpate the location of the anterior border of the masseter muscle under contraction, in relation to the second molar. This is done with the usual trial setup in wax. The *final* arrangement of the teeth starts with the mandibular second molar, the arch developing forward to a point where the distal surface of the maxillary cuspid (as projected to the mandibular cast) coincides with the corner of the vermilion border of the lips. It is surprising how often this length is different on the two sides. Most often it will be found that, by the use of the empiric technique, half of the mandibular second artificial molar will be within the area of the powerful elevator muscles (Figs. 3, 4, 5, and 6). This is undesirable.

Teeth that are set posterior to the anterior contracting border of the masseter muscle are in a position such that the patient can develop a powerful fulcrum at tooth level, which will cause the artificial denture to raise anteriorly during function. A patient can use natural teeth posterior to this border to create a rocking, but, in this case, the temporomandibular joint is frequently traumatized. Also, the insertion of the temporal muscle can be strained,[1] and the periodontal structures around the posterior molars can be harmed. These things occur regardless of vertical dimension of occlusion.

Fig. 1.

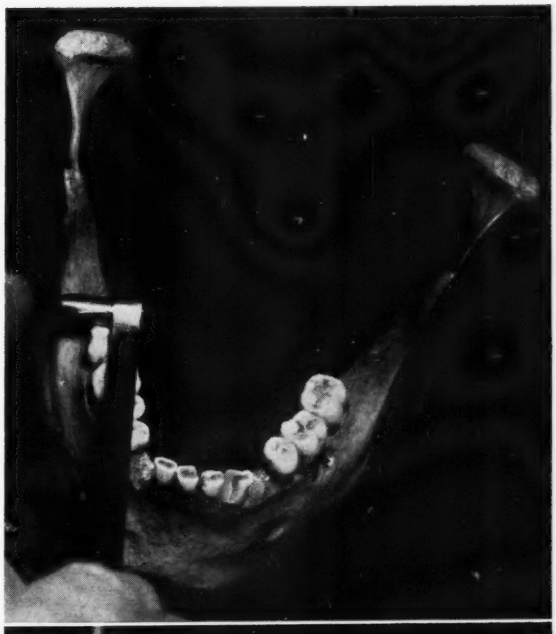

Fig. 2.

Fig. 1.—The use of the Muscle Arch Determiner for locating the anterior border of the masseter muscle when under contraction. On the head of this measuring device is placed a piece of pipet tubing (not shown). The index finger is placed on the cheek in the area where this border is expected to be found. By pointing to the muscle, and directing the patient to contract it gently, the locator point can be moved so as to determine the position of the distal part of the second molar in relation to this contracting border. This is done with the trial setup.

Fig. 2.—The use of the handle of the Muscle Arch Determiner. The handle is 5 mm. wide, and that is the smallest measurement between the buccal surface of the second molar and the external oblique ridge found in the adult. Whenever the body of the mandible (not the alveolar ridge) is large, the distance will approach a 6 to 7 mm. measurement. When the body of the mandible is small, the distance approaches a 5 mm. measurement.

To place the second mandibular molar more accurately, one other measurement is necessary. That is the width or lateral position of this tooth. For several years, I have used the external oblique ridge as a constant from which to project the lateral positioning of the second molar. It has proved very successful. Fig. 2 shows how the handle of the Muscle Arch Determiner is used for this purpose. I have found that the distance between the buccal surface of the

Fig. 3. Fig. 4.

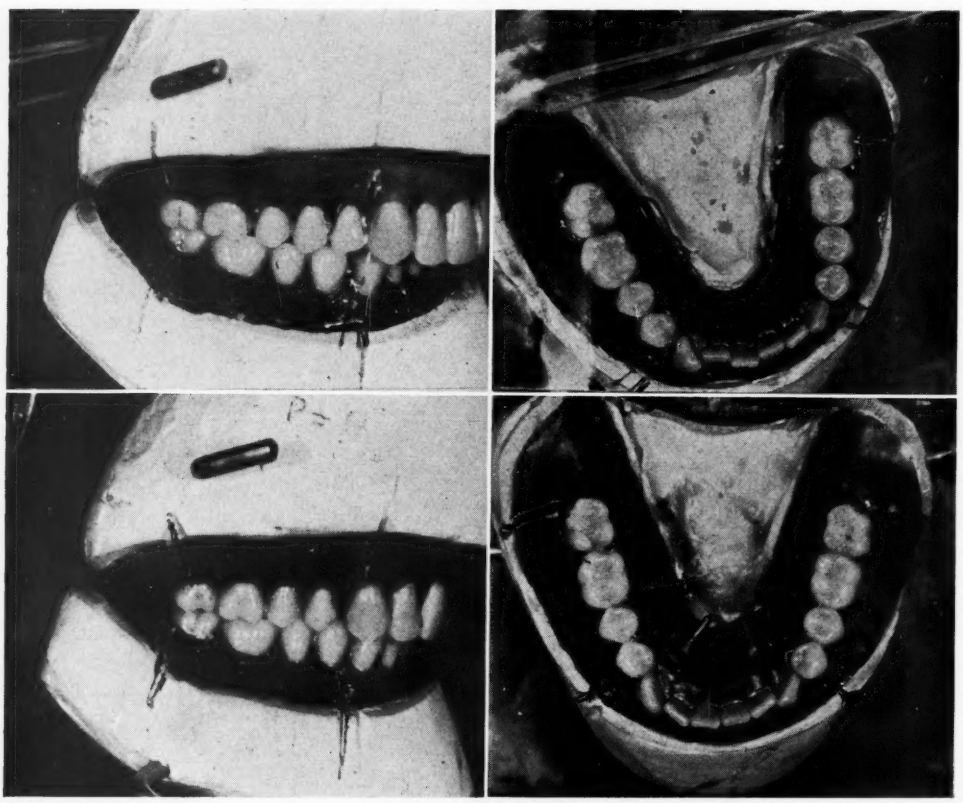

Fig. 5. Fig. 6.

Figs. 3 and 4.—The lateral and mandibular occlusal views of a practical trial setup according to the empiric method. Three bicuspids were used in this setup. The lines indicate the recordings taken from the mouth by using the Muscle Arch Indicator. In this setup, the second molar was placed too far posteriorly in relation to the anterior border of the masseter muscle under contraction, which is indicated by the posterior line. The anterior line marks the position of the distal surface of the maxillary cuspid as projected to the mandibular cast. Compare with Figs. 5 and 6.

Figs. 5 and 6.—The final setup. The mandibular arch was moved forward along with the mandibular anterior teeth. The contacts of the mandibular molars were slightly reduced. This brought the arch forward of the elevator muscles of the mandible. The extra upper bicuspid was removed. Note that the left side of this mandible was shorter anteroposteriorly than the right side. This was an average-size mandible. The external oblique ridge to the buccal surface of the second molar measurement was set at 6 mm. The second molar, masseter muscle relation holds for a wide variety of mandibular sizes. A class II jaw relation must be extreme before the distal surface of the second molar will be within the area of the elevator muscles. A mandible must be extremely prognathic before the distal surface of the second molar will appear to be slightly forward of this muscle.

mandibular second molar and the external oblique line measures between 5 and 7 mm. and that approximately 80 per cent of the measurements were 6 mm. The handle of this measuring device is 5 mm. wide. This is the smallest measurement, and it allows the operator to place it in the space between molar and external oblique ridge, and still palpate the ridge. Where this 6 mm. line bisects the line projected from the anterior border of the masseter muscle under contraction, the important point is established for setting the second mandibular molar (Fig. 7).

Fig. 7.—The landmarks and places where measurements are made on a mandible. *1*, The line from the distal surface of the second molar to the position of the anterior border of the masseter muscle under contraction. *2*, The position at which the distance between the buccal surface of the second molar and the external oblique ridge is made. *3*, The line brought down from the maxillary cast, indicating the location of the distal surface of the maxillary cuspid. *4*, The external oblique ridge. *5*, The outline of the cross section of the masseter muscle. The distance between lines *1* and *3* indicates the measurement for the size of the posterior teeth. The distobuccal corner of the mandibular second molar is located where lines *1* and *2* cross.

This method allows for the variation in width of either side of the jaw, which is the correct manner for teeth to be set in the artificial denture. In many cases, the artificial dental arch does not develop in the symmetrical pattern which the empiric formula dictates (Figs. 3, 4, 5, and 6). The construction of complete dentures in the symmetrical pattern may account for some patients' complaint that *one* lingual side is annoying to the tongue.

This is a method for locating the anteroposterior position of the complete dental arch and the width of the arch at the second molar region on a physiologic basis, and for determining any asymmetry which has developed in the structure of the mandible. This permits the prosthodontist to develop a dental arch which is neurologically acceptable to the patient.

TEMPORALIS MUSCLE

Many anatomists and clinicians have claimed that the posterior fibers of the temporalis muscle can operate to retract the mandible. Also, some go further and claim that these fibers can serve to rotate the mandible. The claims are made on the basis of the nature of the temporalis muscle, with its anterior, middle, and posterior fibers, and with three individual nerve entries into each of these muscle parts. It is assumed that if the posterior fibers should contract, they would retract the mandible. I believe these claims are erroneous.

I have not found any evidence that the temporalis muscle can retract the coronoid process to which it is attached. Nor have I found any evidence that the temporal muscle can rotate the mandible. In my work on cadavers, there was not the slightest suggestion that a posterior contraction was ever exerted at this level. Fig. 8 demonstrates the probable nature of the action of the temporalis muscle. Also, it corroborates in the living patient facts previously recorded concerning the action of the pterygoid externus muscle.[2]

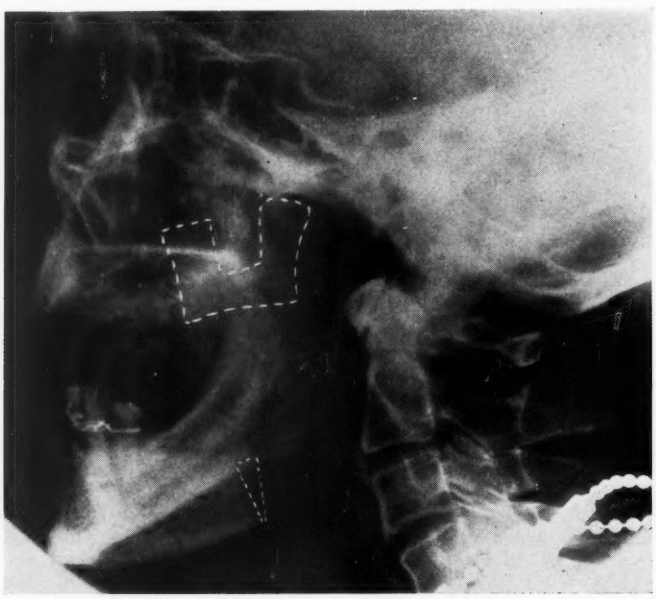

Fig. 8.—A lateral view of a mandible which was resected for the removal of a cancer at the medial side of the right angle of the mandible. The sites of the sections are outlined with dotted lines. The high section eliminated muscles other than the temporalis and the pterygoid externus, thus presenting an opportunity to study muscle action at this level in a living patient. Approximately the lower third of the temporalis muscle bundle is missing.

Some of the literary background has probably directed the thinking concerning the action of the temporalis muscle. In the eighth edition of *Morris's Human Anatomy*,[3] the temporalis muscle, the masseter, the pterygoid externus, and the pterygoid internus are considered to be muscles of the same group. Their action is described essentially as a group action. It is erroneously stated that the "suprahyoid muscles and the external pterygoids are feeble antagonists." I have shown this to be an error,[1, 2] for, at the levels at which they operate, they work

synergistically, to tilt the mandible. It is further and correctly stated[3] that the temporalis muscle serves to elevate the jaw, and incorrectly stated that it aids in producing forward movement of the jaw; "while the inferior-posterior portions of the temporalis muscles carry the jaw at the temporodiscodial joint backwards." Essentially, some of the action of the temporalis muscle is described with some reservation.

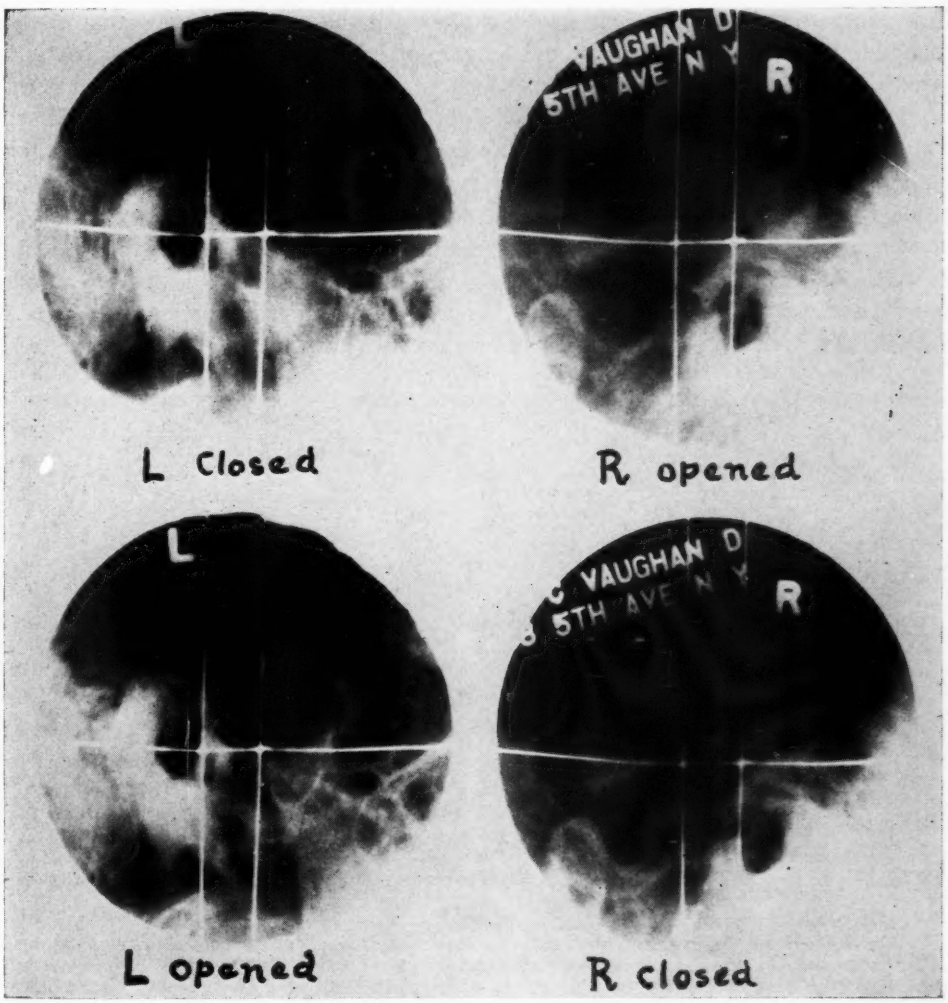

Fig. 9.—The right and left, and opened and closed roentgenograms of the case shown in Fig. 8. Note the left condyle is in the area of a normal position. On the right side, once the external pterygoid contracts, the condyle remains forward, and even though the temporal muscle is attached to this segment, the condyle is not returned to the fossa.

In the eleventh edition of *Morris's Human Anatomy*,[4] the action of the temporalis muscle is described briefly, incorrectly in part, and without any evidence of caution: ". . . to elevate the jaw." (Correct.) "The posterior two-thirds also retract it or, acting unilaterally, rotate it." (Incorrect.) Caution has disappeared.

It is essential to clarify this important point because we cannot advance further in our understanding of mandibular movement and in clarifying much that is wrong, until we understand *specifically* what controls mandibular movement and how it operates. We are at the crossroads where generalization must disappear. The action of the temporalis muscle is directly associated with the important factor of the compensating curve in tooth arrangement. It becomes directly involved with the basic theories of the articulators in use today. It leads to the important and now obvious observation that the primary articulation of the mandible to the skull is not just the temporomandibular joint, but also the temporalis muscle and coronoid process which working as a team (pathology free)[1] establish the first anatomic guiding and controlling units for mandibular action.[2, 5]

Figs. 8, 9, 10, and 11 should be studied carefully for an example of muscles acting at the level of the condyle and coronoid processes. They should be studied, also, in the light of further evidence of many of my previous remarks[1, 2, 6] concerning the nature of the action of these muscles. I believe, from the evidence I have seen, and as shown in these figures, that the action of the temporalis muscle serves to elevate the mandible. The only additional function that can be claimed at this time is that it acts as an arm creating, through the coronoid process,

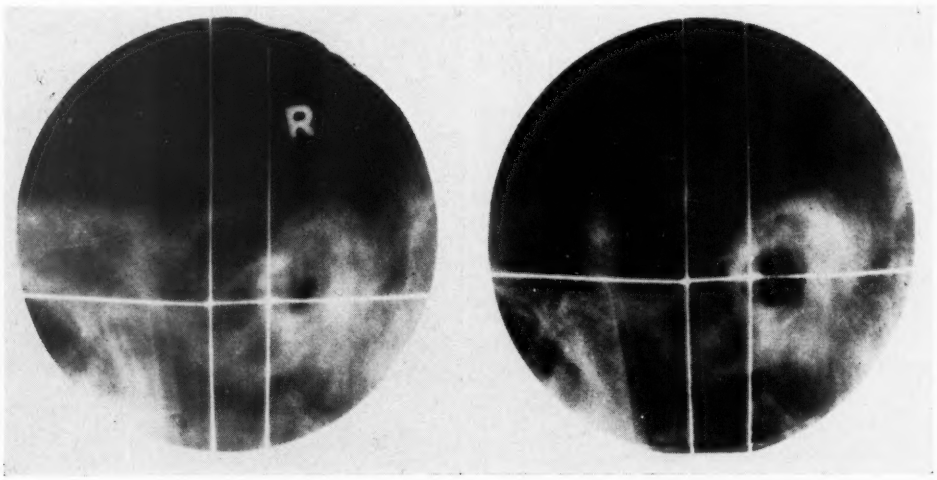

Fig. 10. Fig. 11.

Fig. 10.—On the command to open, a double exposure shows that the condyle moves forward.

Fig. 11.—Roentgenograms of the right side superimposed (i.e., opened and closed as shown in Fig. 9) demonstrate how much movement takes place, and that this movement is superior as well as anterior. Throughout the discussion which follows, remember this resulted from the "command to open." Other points are important also: (1) the accuracy of the Updegrave technique makes it possible to superimpose these two views. (2) The power supplied by the suprahyoid musculature.[6] My original study of the temporomandibular joint pointed out the fact that the suprahyoid musculature takes an active part, and is important in the performance of the opening tilt, etc. Now we can ask—How much vertical opening could the mandible execute with only the external pterygoid muscles? I have stated ". . . the only muscles that can perform 'forced protrusion' or the 'anterior glide' are a pair of external pterygoid muscles."[6] In some instances, the external pterygoids, working in conjunction with the temporal muscles as they do in the patient, would contribute nothing to the vertical dimension of the opening tilt, except the third dimension. In other patients, they can aid, but in none do the external pterygoid muscles contribute greatly to the degree of vertical tilt. The power and the wide range of vertical opening is supplied solely by the suprahyoid musculature.

a pendulum for the mandible. Further, it is as important to the primary articulation of the mandible to the skull as is the temporomandibular joint. The temporal muscle has a specific resting position; lessening of function will occur when it is made to act anterior to position posterior to this.

It is the external pterygoid mechanism,[6] the temporomandibular joint, along with the temporalis muscle and coronoid process, that creates the primary articulation of the mandible with the skull.

This view offers the explanation for many of the discrepancies in techniques in use today. It explains why parts of many techniques are correct and other phases of them are incorrect. It re-emphasizes the fact that pathology or injury to any of these parts is considered by most as temporomandibular joint pain. This concept gives me an opportunity to stress again the importance of a diagnostic technique thorough enough to differentiate between the elements of the primary articulation that might be involved.

SUMMARY

The importance of the position of the second mandibular molar in the complete denture has been developed. A technique has been offered for the accurate positioning of this molar in the artificial complete and free-end partial denture arch. This technique considers the physiology of the part and reconstructs any changes in the structure of the adult mandible as they are related to tooth position. Through this method, it is possible to relocate the complete denture arch in its correct anteroposterior relation to the masticatory muscle mass, to determine the anteroposterior size of the molar teeth, and to establish the correct width of the arch at the region of the second molar tooth.

The action of the temporalis muscle has been described with the thought that we must claim less for its action than has been done.

The primary articulation of the mandible to the skull has been discussed. A few of the important implications have been pointed out as they relate to this subject.

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A SPLINT FOR AN ACROMEGALIC PATIENT

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THIS IS A CASE REPORT of the construction of a prosthetic appliance to establish the vertical dimension and a functional occlusion for an acromegalic patient.

HISTORY

While the patient was in Naval Service in 1943, he first noticed his increase in size.[1] He was hospitalized and treated several times for acromegalia. In 1952, he was given a medical discharge from service.

On April 7, 1953, the patient was admitted to the Veterans Administration Hospital at Seattle, Washington, with a primary diagnosis of acromegalia, active, a secondary diagnosis of personality disorder. He was referred to the dental clinic for a routine examination.

DENTAL EXAMINATION

Enlarged features typical of the disease were apparent. However, the patient did not appear prognathic as sometimes is the case in acromegalia (Fig. 1). The mouth had a clean and healthy appearance. Several small mandibular tori were present. There was no apparent pathology of the tongue, hard palate, or mucous membrane of the oral cavity. Dental roentgenograms did not disclose any apparent pathology of the teeth or bone.

The dentition was complete except for the two lower third molars and the upper left third molar. All teeth present were in good repair. The maxillary and mandibular teeth were spaced, and there was a slight increase in the interocclusal rest distance (Fig. 2). A cast gold splint had been constructed over the posterior teeth on the lower right side. A gold and acrylic resin splint had been constructed over the posterior teeth on the lower left side (Fig. 2,*A*). The occlusal surfaces of these splints were flat with some recessed sluiceways. The mandible had increased in size until there was no occlusion between the maxillary and mandibular teeth in centric position (Fig. 3). Contact could be made between two teeth in the right lateral excursion, but none was possible in the left lateral excursion. It was impossible for him to masticate food.

TREATMENT

Concurrent with the medical treatment of the patient, the following dental treatment was rendered.

Received for publication Jan. 25, 1956.
Photography by H. Paul Newman.
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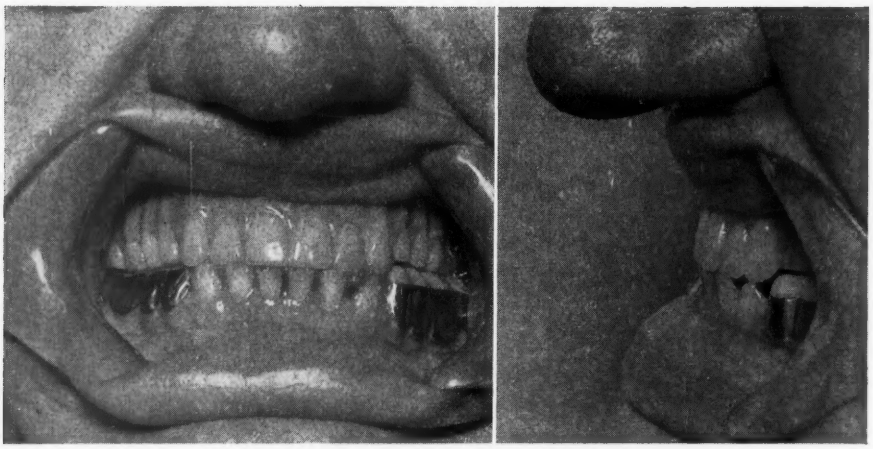
It was decided to fabricate a removable splint to be worn over the maxillary teeth. This decision was made for two reasons. First, because the extensive restorations which had been accomplished on the lower posterior teeth appeared to be in excellent condition. Second, it was not known whether the growth of the mandible had been, or would be, arrested.

Fig. 1.—The patient had the typical appearance of an acromegalic.

Study casts were made from alginate impressions. These were mounted on an articulator with the aid of a face-bow, and a wax interocclusal record (Fig. 3). A clear acrylic resin splint was made first to determine whether the patient could and/or would tolerate this type of an appliance. This splint had flat occlusal surfaces in the posterior regions, and indentations made by the incisal edges of all of the lower teeth. The buccal and labial surfaces were contoured to fill out the lips and cheeks. At its insertion, the patient was instructed in the care of the splint and the necessity for strict maintenance of oral hygiene. After several



A. *B.*

Fig. 2.—The teeth were spaced and there was an increase in the interocclusal rest distance. Note the splints on the lower posterior teeth.

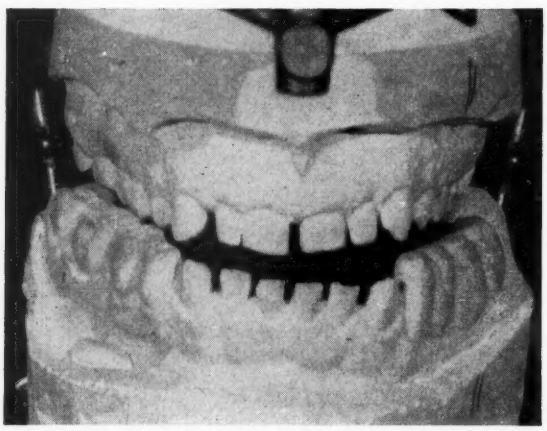


Fig. 3.—The difference in the size of the jaws made mastication impossible.

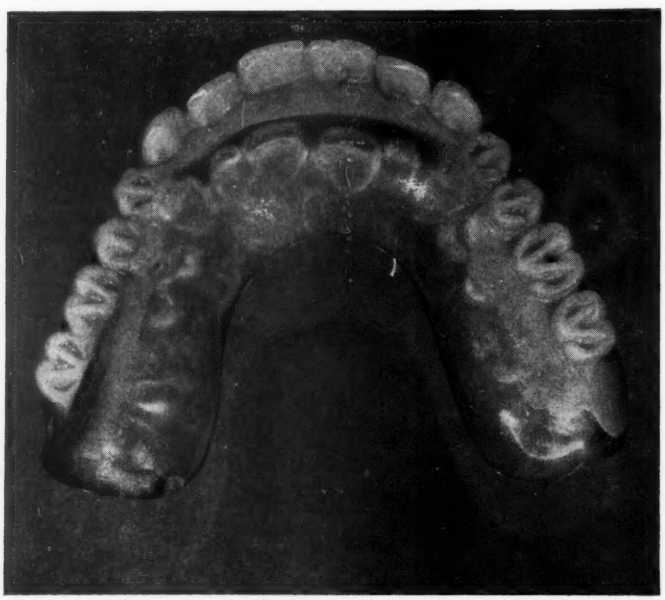


Fig. 4.—A transparent acrylic resin splint was constructed and teeth were added to the splint.

adjustments, he was able to wear and use this appliance comfortably for a trial period of six weeks. Then another clear acrylic resin splint was made which duplicated the established occlusal vertical dimension and the facial contours developed with the first splint.

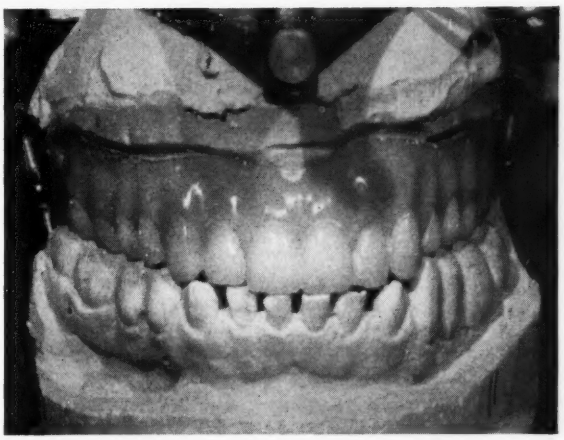


Fig. 5.—The occlusion was corrected on the articulator.

A. *B.*

Fig. 6.—The completed restoration.

This second splint was mounted on the articulator with the aid of a face-bow, The splint was then removed and used to establish centric occlusion by luting soft wax on the occlusal and incisal surfaces and then having the patient close in centric position. The cast of the lower teeth was mounted on the articulator by using the centric interocclusal registration on the upper splint. The clear acrylic resin of the splint was cut away from the buccal and labial tooth areas to allow for the positioning of the teeth which were arranged for function and esthetics. This set-up was tried in the mouth for final adjustments. The splint was then reprocessed to attach the teeth and the pink acrylic resin to the labiobuccal surfaces of the clear acrylic resin splint (Fig. 4).

After processing, the splint was remounted on the articulator to eliminate the processing errors (Fig. 5).

The result was an appliance that established the occlusal vertical dimension, the functional occlusion, and was esthetically acceptable (Fig. 6).

SUMMARY

1. The progress of this acromegalic patient has been under observation for over two years. During this period the patient was seen on many occasions.

2. The splint has proved to be entirely satisfactory functionally.

3. If the mandible should enlarge still further, the appliance would have to be remade.

4. The patient's mental outlook was immeasurably improved.

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A STUDY OF ENAMEL ABRASION AS RELATED TO PARTIAL DENTURE CLASPS

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ONE OF THE MOST important steps in the successful construction of a partial denture is the design of the appliance. Friction between the clasp and the tooth is mainly responsible for the retention of the well-designed partial denture. Generally, this frictional retention is accomplished by the use of specialized retainers in the form of metal clasps.[1,2] The efficiency of the clasp depends upon many factors, some of which are closeness of adaptation to the tooth, resiliency, and strength. It is often recommended that the clasp be, as nearly as possible, perfectly adapted to the tooth surface in order to secure proper retention and to minimize the possibility of nonhygienic conditions under the clasp.[3]

Various techniques and materials have been utilized in the construction of clasps for partial denture appliances, and controversy still exists concerning the ideal design or material. There has always been argument[2] that any type of clasp is contraindicated because the frictional action against the tooth will abrade enamel. However, both Kennedy[1] and Prothero[2] emphasize that the real danger may be improper design or hygiene, which leads to plaque and bacterial accumulations which invite decalcification and caries. There is no evidence in the literature in regard to the exact relationship of abrasion of the clasp itself against enamel and its clinical significance.

This particular problem has been somewhat magnified in recent years due to the increased popularity of the chromium-cobalt alloys. It has been estimated that in this country today the ratio of use of base metal alloys to gold is five to one.[4] One of the serious objections to this type of alloys for partial dentures has been on the basis of their inherent physical properties. It has been claimed that the high hardness coupled with a high modulus of elasticity, as compared to gold alloys, would produce enamel abrasion. It is true that examination of these physical properties, at least on a theoretical basis, might lead one to make these predictions. Although there is no accepted test for abrasion,[5] hardness has long been used as a key to this property, i.e., a hard material will tend to abrade one which is softer. Since the hardness of enamel[6] is much lower than that of the base metal alloys, it is suggested that abrasion could result. The problem is accentuated because of the high modulus of elasticity which might contribute to wear on the tooth surface during removal and insertion of the appliance.

This research was supported in part by a grant, AF 18(600)-936, from the School of Aviation Medicine, Randolph Field, San Antonio, Texas, U.S. Air Force.

Received for publication Feb. 24, 1956.

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Despite these theories, there is no evidence to indicate that the metal clasp, irrespective of design or composition, will abrade enamel. Since abrasion, even though minute, may eventually lead to incipient caries and loss of retention, this problem appears to be a vital one.

PROCEDURE

A. *Preparation of Specimen and Clasp Design.*—The initial factor to be considered was the type of test specimen to be utilized in this research. It was felt that even though individual human teeth, and different areas of the same tooth, vary markedly in their hardness[6,7] no other suitable substitute could be employed. Use of a material such as metal or porcelain would make possible a more uniform specimen; however, abrasion on one of these materials might not be of the same magnitude as compared to the tooth. Thus, extracted human teeth were deemed necessary for a sound clinical correlation of the data to be obtained.

Disassociated teeth, preferably unerupted third molars, were used throughout this study. They were examined microscopically for any surface imperfections, caries, or instrument marks on the areas which normally would be in contact with the clasps. Only those free of these deficiencies and those having a surface contour of suitable undercut were used. Unless otherwise stated, the teeth were stored in tap water.

The teeth were mounted in an autopolymer, 1 inch apart (Fig. 1). Care was taken to establish the position of the tooth in such manner that a 0.020 inch undercut where the retention part of the clasp embraced the tooth would be established. The teeth were also located in the base so that a perpendicular path of insertion of the clasps would be possible. It will be noted that, when viewed from the occlusal surface, the acrylic resin has been cut away from the tooth to expose the coronal portion. This was done in order to silhouette the height of contour.

To secure maximum retention, the clasp must be properly oriented on the tooth. Naturally the retentive tips of the clasps must be placed below the height of contour for stability and to prevent lateral movement. As the patient removes and inserts the partial denture, these clasp tips pass over the height of contour. With the advent of the Ney Clasp surveyor, the positioning of the clasp with the bracing portion along the height of contour and the retentive portion below the bulbous part of the tooth has made clasp construction a more scientific art. All clasp construction in this study was by the use of the Ney system of surveying.

A No. 1 clasp was the principal design employed throughout this research (Figs. 2 and 3). This particular clasp was selected for several reasons: (1) it is the design most commonly used; (2) its twofold property of retention and bracing produced maximum enamel contact, and thus made it ideally suited for this study; and (3) it is simple to design and fabricate. There was one minor alteration made in the basic design commonly used. The tips of the retentive arms of the clasp were extended approximately 2 mm. beyond the area normally embraced. This made it possible to provide more surface contact between the clasp and the tooth.

The teeth were surveyed, and the desired undercut was determined by use of the 0.020 undercut gauge. This degree of undercut is the maximum usually

recommended in the construction of No. 1 gold clasps.[3] Due to the high modulus of elasticity of the base metal alloys, it is recommended that only 0.010 undercut be utilized in the construction of partial dentures made of these materials.[5, 9] Use

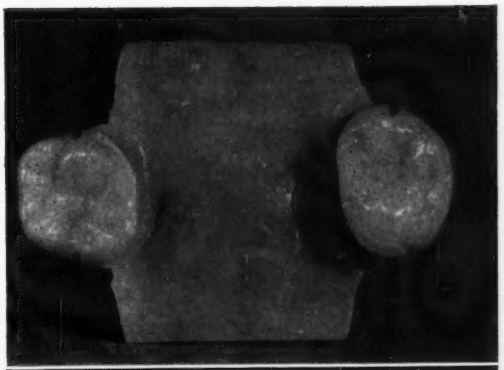


Fig. 1.

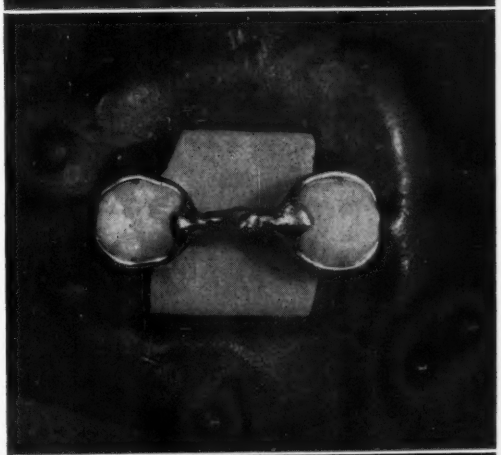


Fig. 2.

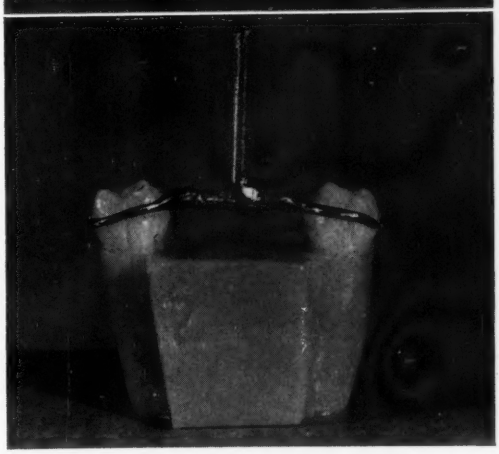


Fig. 3.

Fig. 1.—Extracted teeth mounted in an acrylic resin block. The notches cut in the enamel were used for aligning silhouette negatives.

Fig. 2.—No. 1 clasps in position on tooth. All teeth were surveyed for locating the clasps.

Fig. 3.—Side view showing the perpendicular rod for attaching the clasps to the machine.

of undercuts greater than this would make removal of the appliance extremely difficult. However, in order to magnify any abrasive tendencies of the base metal clasps, the 0.020 undercut gauge was also employed with these alloys. If abrasion could not be detected under these conditions, it would not take place when the recommended smaller undercut was used.

The teeth were duplicated and clasps waxed on the duplicated model, using prefabricated clasp forms. The two waxed clasps were joined by an 8 gauge wax sprue which was parallel to the base. Midway between the two clasps another rod was placed at right angles to this bar. This rod (Fig. 3) was necessary for attaching the clasps to the machine which was to move the clasps on and off the tooth. The gold clasps and framework were cast according to the manufacturer's recommendation.

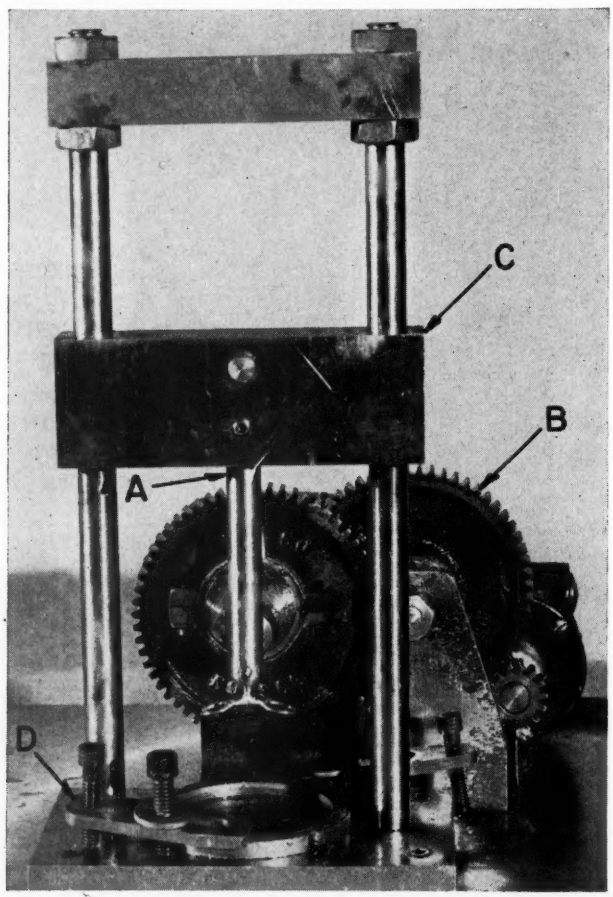


Fig. 4.—The apparatus constructed for mechanical placing and removing of clasps.

A representative alloy, Ney G-3, was used throughout for all noble metal castings. The published Brinell hardness for this gold is 225 in the hardened condition. Base metal castings were fabricated from Nobilium, Vitallium, and Ticonium. The Nobilium castings were made at Indiana University School of

Dentistry, while the Vitallium and Ticonium castings were made in commercial laboratories in Indianapolis. The inside surfaces of both gold and base metal clasps were polished. The upper and lower edges of the clasps were slightly beveled and polished.

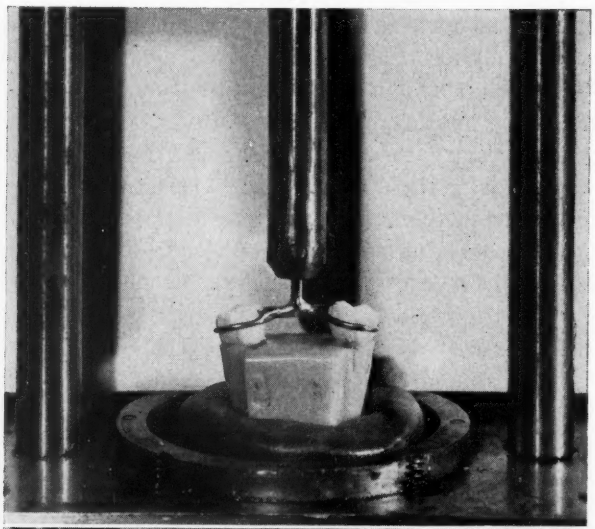
B. *Test Methods.*—There are two possible ways by which a partial denture clasp might abrade the enamel surface. One is from the wear on the tooth by the repeated removal and insertion of the partial denture by the patient. The second factor could be the abrasion induced by the continual friction of the clasps against the enamel during masticatory stresses. In order to study these two factors individually it was necessary to design specialized equipment to stimulate the behavior of the clasps under these conditions. The first apparatus (Fig. 4) was designed to place and remove, mechanically, the casting on and off the teeth. A shaft *(A)* is moved up and down by a series of gears *(B)*. During movement, the shaft is maintained in a true vertical position by means of a heavy machined framework *(C)*. The clasp is centered in this shaft by means of the previously mentioned perpendicular cast rod *(A)*. The rod was held in the shaft by means of an adjustable setscrew in such a manner that when the clasp was seated on the tooth, the shaft was at the bottom of its stroke (Fig. 5). In Fig. 6 can be seen the position of the clasp above the teeth at the top of the stroke. Care was taken that the path of insertion of the clasps on the teeth would be perpendicular in order to reproduce the path of the original survey. This was accomplished by placing the acrylic resin base in soft modeling compound, and allowing it to harden after the desired clasp position was obtained. Once the teeth were properly positioned in relation to the path of insertion of the clasp, they were secured by means of adjustable braces *(D,* Fig. 4).

The motor was so geared that during an interval of one minute the clasps were removed and inserted upon the teeth approximately 10 times; in other words, each clasp passed over the height of contour of the tooth 20 times per minute. It was estimated that if the average patient removes the appliance a minimum of two times a day, the clasps would be passing over the height of contour four times a day or 1,460 times a year. Removal four times a day would mean approximately 2,720 times per year. On the basis of these rough approximations, it was decided to run each series for a minimum of 25,000 strokes, which is equivalent to the clinical wear to which the tooth would be subjected during approximately sixteen years if the partial denture was removed twice a day, or eight years when removed four times a day. Tests were made with the teeth dry as well as immersed in saliva throughout the test period. The teeth were examined at each 6,000-stroke interval.

It is the belief of some that it is not the removal and insertion of the partial denture that produces abrasion, but rather the movement of the clasps on the teeth during mastication. There is little doubt that even in the well-designed denture, the clasp does move slightly on the clasped area of the tooth surface. The resistance of the tooth to this movement could possibly produce abrasion. Since the above-described apparatus would not duplicate this particular type of movement, a different test was required.

A photograph of the apparatus can be seen in Fig. 7. The principle involved was to utilize a vibratory motion of clasp against the tooth. The most convenient way of accomplishing this motion was to hold the clasp stationary and vibrate the tooth against the clasp. Therefore, the clasp was fixed and held securely in

Fig. 5.



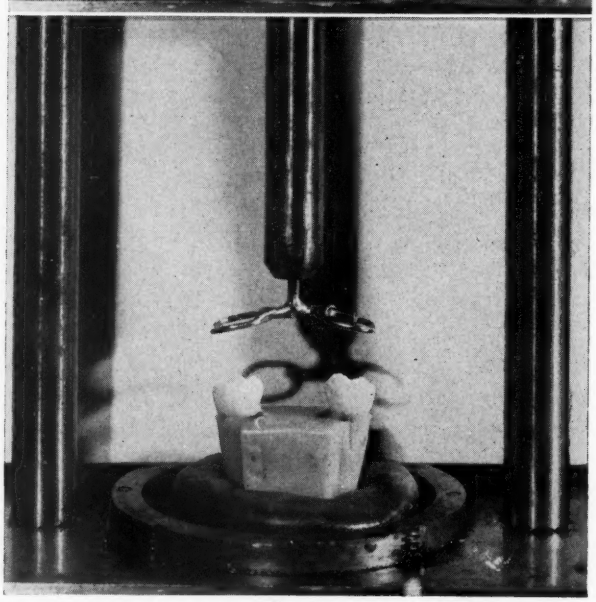


Fig. 6.

Fig. 5.—Clasps in position at the bottom of the stroke.
Fig. 6.—Clasps at the top of the stroke.

a stationary position by a perpendicular rod *(A)*. The teeth were mounted on an acrylic resin platform *(B)*. The platform in turn was fastened to coiled springs, the purpose of which was to set up the vibratory action. A 25 pound weight was placed on top of the rod. This procedure helped to standardize the force of the

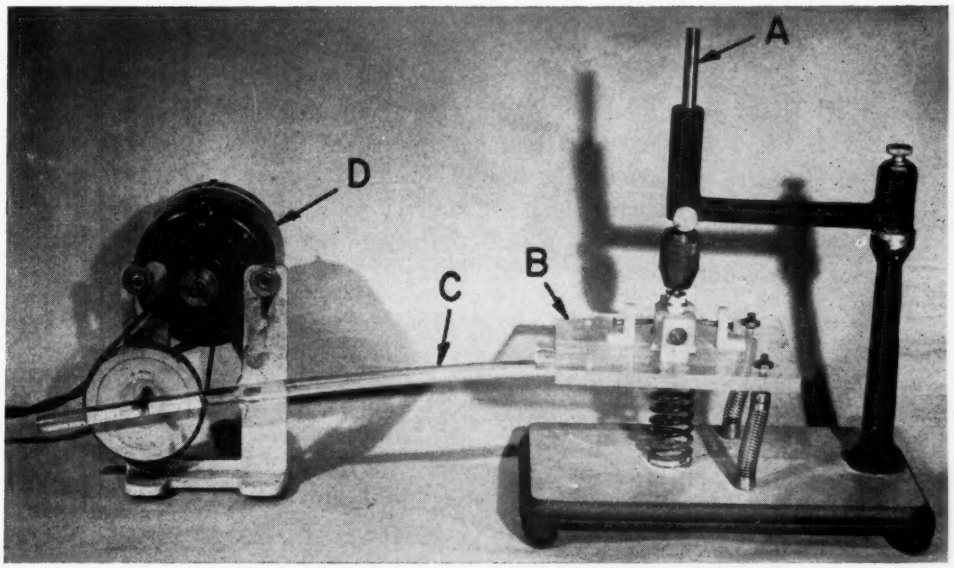


Fig. 7.—The apparatus for vibrating the clasp against the tooth surface.

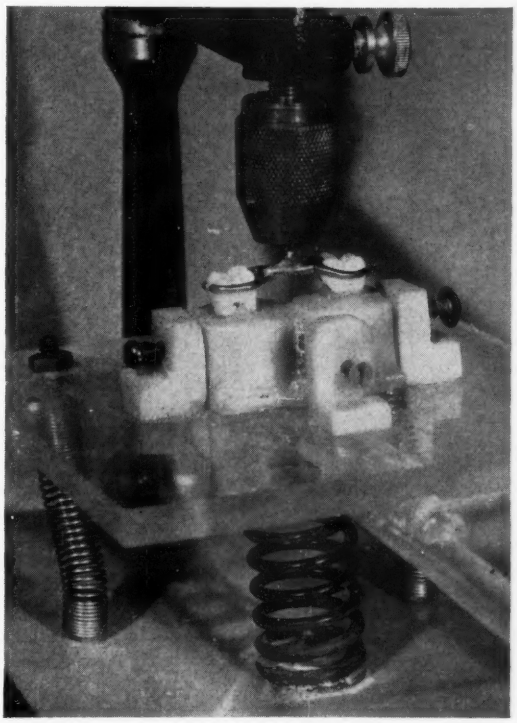


Fig. 8.—The clasps are fixed, and the tooth is vibrated vigorously against the clasp.

clasps on the teeth as well as the tension on the coiled springs. A solid acrylic rod *(C)* was attached to the middle of the platform, and the end of this rod was vibrated by an eccentric flywheel attached to a 1/150 H.P. motor *(D)*. A close view of the platform with the teeth and clasps in position can be seen in Fig. 8.

There was no convenient means of measuring the actual magnitude of vibration at the critical point where the clasp touches the tooth. It is sufficient to point out that the vibration was severe and uniform for each series of specimens. It was difficult to determine the length of time the tooth should be vibrated in order to duplicate the conditions existing under normal mastication. A standard test period of 40 hours was arbitrarily selected. Since the clasp was actually moving on the tooth surface, through a small arc in every plane, literally hundreds of times per minute, this testing interval should simulate many years of clinical wear as induced by masticatory stresses.

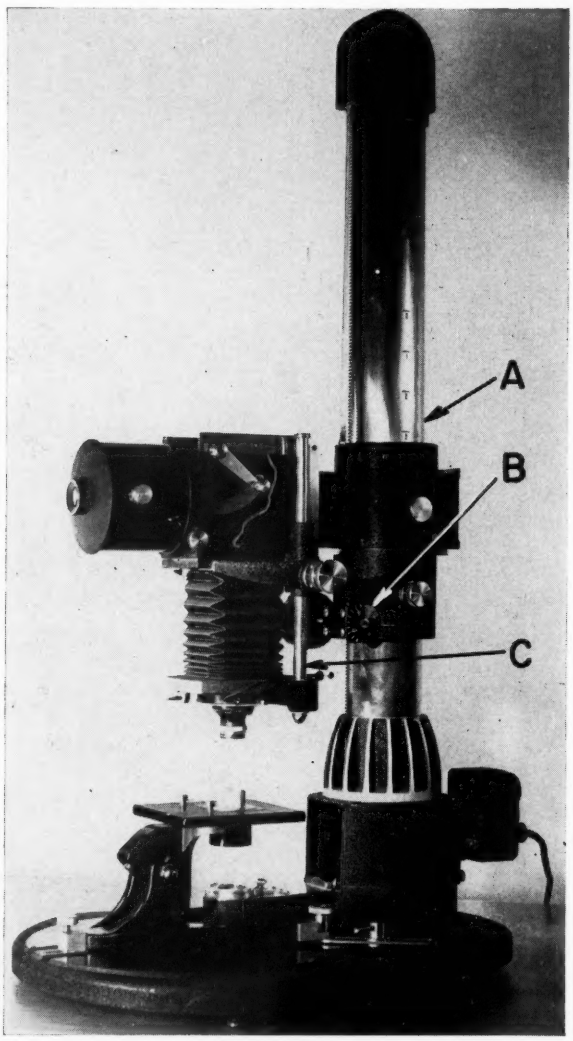


Fig. 9.—The photomicrograph microscope used to record the silhouette of the tooth contour.

C. *Method of Evaluating Abrasion.*—Various possible methods for recording and measuring the abrasion were considered and tried. The final technique established was a photographic method of silhouetting the height of contour of the

tooth. This procedure proved to be workable and accurate for this study. The silhouetting technique is a principle widely used in industry (Kodak contour projector), and has been employed to a limited extent in dental research.[10, 11]

It is obvious that if abrasion results when the patient removes and inserts the partial denture, then wear would occur at the height of contour. As the tips of the clasps pass over the bulbous portion of the tooth, abrasion must take place at the height of contour. Thus, the method employed was to silhouette this area of the tooth at the beginning of the test, and then by means of subsequent photographs determine any abrasion that would be produced.

Fig. 10.—A tooth in position for photographing the silhouette.

An Orthophot photomicrograph microscope was employed (Fig. 9). A Kodak M plate of panchromatic sensitivity and high resolving power was used. The specimen was mounted on the stage of the microscope (Fig. 10) and direct diffuse light, passing through ground glass, was used to silhouette that portion

of the crown over which the retentive parts of the clasps passed. After focusing on this original height of contour, readings were taken of the various scale settings (*A, B,* and *C,* Fig. 9) in order that the teeth could be reoriented for subsequent photographs.

In order to familiarize the reader with the photographs to be used in this article, a silhouette of a typical tooth with the clasp resting at the height of contour can be seen in Fig. 11. The location of the retentive parts of the clasp are easily seen. It is this area, then, which would be abraded, and which was carefully studied to determine whether any surface changes did occur. (The clasp was, of course, removed before the silhouette was taken.)

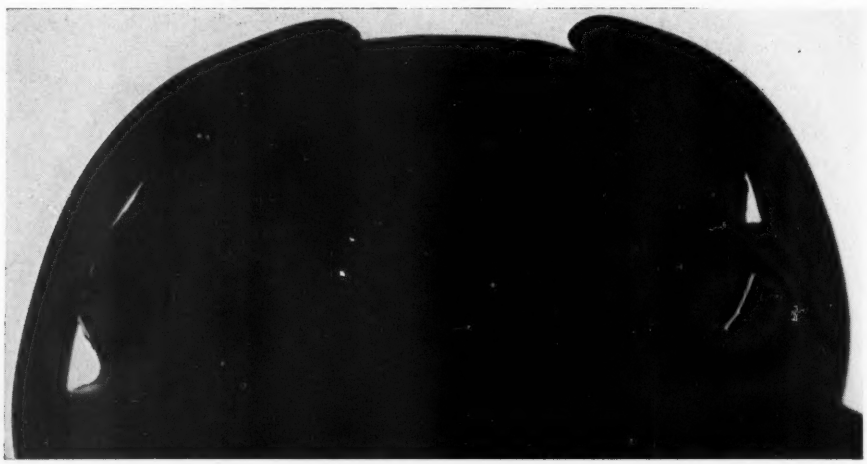


Fig. 11.—A silhouette showing the position of the clasps on the tooth. The clasps are removed when a silhouette of contour is made.

For direct comparative purposes, the silhouette negatives were superimposed, using the original silhouette as the control. In order to orient each negative properly, two notches were placed on the buccal and lingual surfaces of each tooth (Fig. 1). In this manner, the negatives were placed one on the other, aligning the notches, and a print was made to show any loss of tooth structure at the height of contour.

It was felt that some type of test should be devised to check the sensitivity of this photographic method. If the silhouetting technique would not accurately record minute surface changes, then some other means would be required for measuring the degree of abrasion on the subsequent photograph. A special steel gauge rod was machined. This rod was ⅜ inch in diameter in order to approximate the average bucco-lingual width of a tooth. Using this diameter as the original control, the remainder of the rod was turned down in a series of three additional graduated sections. The diameters of the sections decreased from the original as follows: 0.001 inch, 0.003 inch, and 0.007 inch. This graduation provided a series of cylinders of known diameters which were silhouetted in the manner previously described. The silhouette of each cylinder was then in turn superimposed upon the negative of the original control. When properly aligned along one edge, differences in the negatives can be readily detected as shown in Fig. 12.

The difference in the size of the specimens is seen as a gray line indicated by the arrow. This line is produced by the difference in density of the two superimposed images. The width of this line proved to be in direct proportion to the difference in diameter of the test rods. It is apparent, therefore, that this technique is adequate to detect magnitudes of abrasion which cannot be seen visually. Changes of 0.001 inch (25.4 microns) can be recorded readily.

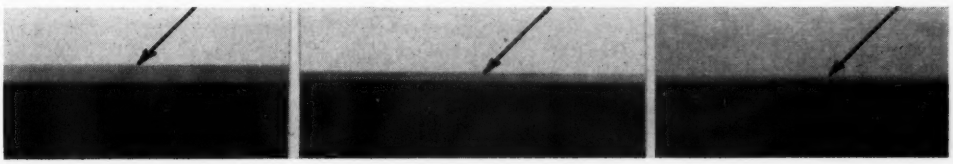


Fig. 12.—Results on a test block used to check the sensitivity of the method. The gray line is produced by the difference in density of superimposed images. The line at the left represents 0.007 inch, middle is 0.003 inch, and smaller line at right is 0.001 inch. These tests prove that the method is accurate for recording small magnitudes of abrasion.

In addition to this basic method of measuring abrasion, all areas of the tooth which were to be embraced by the clasp were carefully studied, both before and after completion of the test, using visual and low power (X10) examination.

RESULTS

In Table I can be seen the number of teeth which were used for each type of clasp material and for both the wet and dry conditions. These teeth were all abraded with the first apparatus described (Fig. 4). Each tooth was carried through the 25,000-stroke cycle. In one-third of the tests for each clasp material, to exaggerate the wear, the retentive tips of the clasps were adjusted by bending inward. The force required to remove the clasps was approximately 50 per cent greater as measured by a Tinius Olsen machine.

TABLE I.—NUMBER OF TEETH USED WITH EACH TYPE OF ALLOY EMPLOYING THE APPARATUS SHOWN IN FIG. 4.

CLASP MATERIAL	IMMERSED IN SALIVA	DRY
Gold	71	68
Nobilium	90	89
Vitallium	48	51
Ticonium	52	56

Since hundreds of silhouettes were recorded during this investigation, only a few representative photographs will be used to illustrate the results obtained. A typical example can be seen in Figs. 13-15.

Regardless of the clasp material used, no *visual* evidence of abrasion was noted on any specimen. On two teeth, the silhouettes showed a slight area of abrasion (one clasp Vitallium and the other Nobilium) after 25,000 strokes on a *dry* tooth. These teeth are shown in Figs. 16 and 17. The slight gray shadow of the abraded area is evident. In comparison to the standards (Fig. 12), this abrasion is no greater than 0.001 inch and would not be clinically significant.

TABLE II.—NUMBER OF TEETH USED WITH EACH TYPE OF ALLOY EMPLOYING THE APPARATUS SHOWN IN FIG. 7.

CLASP MATERIAL	IMMERSED IN SALIVA	DRY
Gold	40	38
Nobilium	57	53
Vitallium	34	36
Ticonium	30	32

The results obtained with the vibratory apparatus substantiated these observations. In Table II can be seen the summary of the tests made. No abrasion was detected on any tooth after the 40-hour abrasion period.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 13.—A silhouette of the original contour of a tooth.
Fig. 14.—The contour after 25,000 strokes on a dry tooth with a Nobilium clasp.
Fig. 15.—Superimposed negatives, shown in Figs. 13 and 14, show no abrasion.

Another facet studied was abrasion of the clasp as related to metallic restorations. Many times the partial denture clasp will rest upon a gold inlay, crown, or an amalgam restoration.[8] Two-surface amalgam restorations were placed in 56 teeth and clasps were constructed from gold and Nobilium. Both materials produced severe abrasion on all restorations, the effect of the base metal alloy being slightly greater. The abrasion is quite evident visually in the photograph of one representative restoration after 25,000 strokes of a gold clasp (Fig. 18). These results clearly indicate that an amalgam restoration should not be a bearing surface for a partial denture clasp.

Fig. 16.

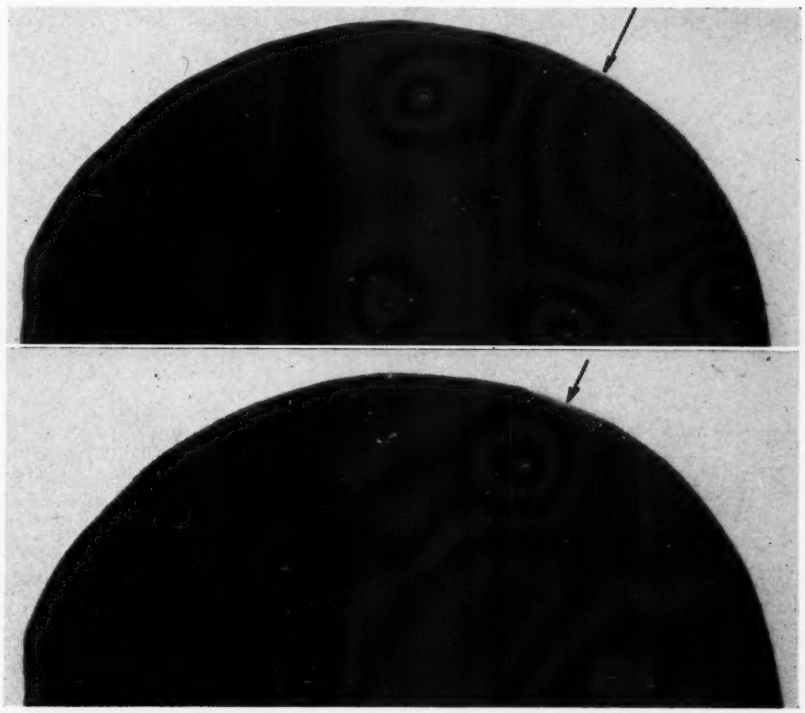


Fig. 17.

Figs. 16 and 17.—Small areas of abrasion, as shown by arrow, following 25,000 strokes of base metal clasps on a dry tooth. These were the only two specimens on which abrasion was noted.

Forty-two teeth were prepared for full cast crowns which were cast with a medium-hard gold. Again clasps of both gold and Nobilium were used. Although burnished areas were noted (Fig. 19), no abrasion could be detected on the silhouettes. There seems to be no deleterious effect with either gold or base metal clasps upon a medium-hard gold restoration. The effect on a soft gold was not studied.

Another factor which may influence abrasion is the pH of the oral environment. If accumulation of debris, plaque, or a lowered pH of the saliva would soften the enamel surface, then that area might be more susceptible to abrasion. A series

of 36 teeth were included in this series. Base metal clasps were used. Eighteen teeth were immersed in pH 5.5 buffered acetic acid solution during the 25,000-stroke test period while the other 18 were immersed in a pH 6.0 acetic acid solution. No evidence of abrasion was detected on any specimen. Results of this series indicate that acid solutions, at least at this pH range, do not accentuate abrasion of the clasp. It must be remembered, of course, that the pH may be much lower if unhygienic conditions exist.

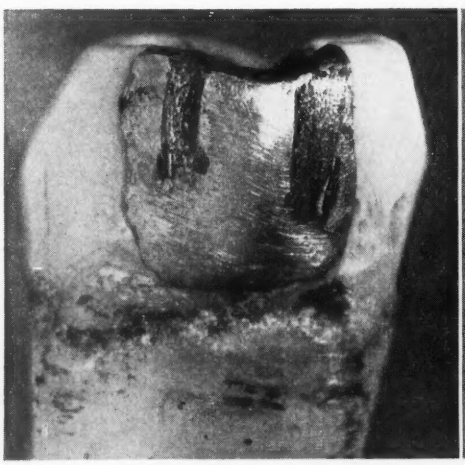


Fig. 18.

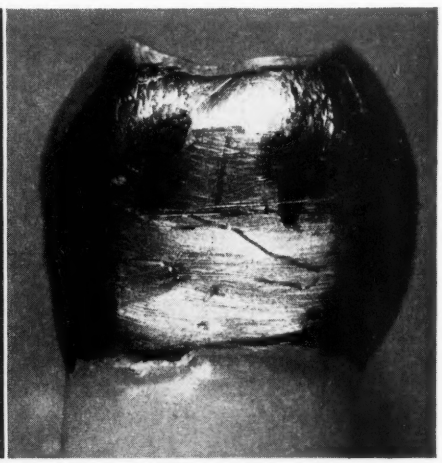


Fig. 19.

Fig. 18.—Visual evidence of abrasion on an amalgam restoration after 25,000 strokes of a gold clasp.

Fig. 19.—Burnished areas on a gold crown due to a clasp. The silhouette showed no measurable abrasion.

DISCUSSION

There are many other facets which have not been included in this study. Factors such as clasp design, finish of the clasp, etc., were not evaluated. However, in view of the accelerated and exacting tests used, and the large number of teeth employed, abrasion of enamel due to the partial denture clasp itself appears most improbable, regardless of clasp design or alloy used. The clasp used presented maximum conditions for abrasion. The long test period coupled with the extremely well-adapted clasp, degree of undercut, and dry tooth surface certainly presented conditions more heroic than the normal clinical case.

Decalcification, caries, and *apparent* abrasion or erosion are often detected under dental clasps. This study in no way indicates what the main causative factor may be in these instances, but it has shown that they cannot be attributed to abrasion of the clasp. Other suggested factors such as unhygienic conditions on the clasp or on the tooth, areas of decalcification, and possible dissolution of enamel due to galvanic currents[12] need study.

CONCLUSIONS

Methods for simulating abrasion of partial denture clasps upon enamel, and for measuring such abrasion have been presented. Clasps constructed of gold and

three different base metal alloys were evaluated. The experimental conditions, in terms of length of test, clasp design, and dry tooth surface, were considered most severe.

Of the large number of individual specimens used, only two teeth showed minor areas of abrasion, and these were not visible to the naked eye. Thus it is apparent that the partial denture clasp, regardless of type of alloy used, does not produce abrasion on enamel. *Apparent* abrasion or erosion commonly seen under clasps must be attributed to other causes.

Severe abrasion was noted when amalgam restorations provided the bearing surface for either gold or base metal clasps. No abrasion was noted when a medium-hard gold was used for the restorative material.

The authors wish to acknowledge the capable assistance of Mr. Robert Callis during the course of this investigation, and the photography of Mr. Richard Scott.

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PARTIAL DENTURE DESIGN AND ITS RELATION TO FORCE DISTRIBUTION AND MASTICATORY PERFORMANCE

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THE PRIMARY PURPOSE OF the masticatory system is the comminution of food preparatory to deglutition and digestion. In the process of masticating a bolus of food, the forces of mastication are transmitted to the teeth and supporting structures. The capacity of the teeth and supporting structures to resist these forces will result in either beneficial, physiologic stimulation, or harmful, pathologic trauma. Therefore, it is imperative that the stresses exerted upon the various components of the masticatory system during masticatory and nonmasticatory movements be confined well within the physiologic limits of tolerance.

It is difficult to analyze and *measure* the various forces that act upon the component structures that make up the masticatory stroke, and, because of this difficulty, there remain wide horizons for dental research. For example, given a bolus of food, with a certain volume and resistance, consideration must be given to such physical factors as the amount of force that is necessary to penetrate the bolus, the direction of the force, and the relative point of application. Other factors include the spacial maxillomandibular relationships, and whether the masticatory strokes are sustained, rhythmic, regular, irregular, fast, or slow. Added to these, the effect of partial denture design also enters into the resistive component of the bolus of food, and must be considered as means of distributing stresses.

The maintenance of oral health and efficiency of a restored, partially edentulous mouth is basically dependent upon a proper oral diagnosis and treatment plan. The requirements of a properly designed partial denture necessitate a comprehension of biomechanical principles, together with due attention to each detail in the fabrication process. By means of a proper design, a partial denture should reduce the stresses imposed upon the teeth and supporting tissues; it should distribute the forces over as wide an area as possible; it should contribute to occlusal harmony; and it should control, or at least favorably influence, the direction of the vertical and horizontal stresses.

The effect of partial denture design on static force distribution has been studied.[1-3] The objective in this undertaking is to study, by electronic means, the effect of partial denture design on functional force distribution as it is related to the supporting tissues. In addition, a study will be made to determine what effect

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Received for publication Feb. 27, 1956.

the variations of partial denture designs has on masticatory performance. As a concomitant study, the influence of the size of the occlusal table on force distribution, and masticatory performance will also be studied.

TEST PARTIAL DENTURE

A patient was selected whose remaining teeth were of the same number, distribution, and position as has been reported in previous studies.[2,3] The maxillary arch had a full complement of teeth, except for the missing third molars. The ridges were well formed, and an adequate interarch space was present to permit the fabrication and placement of interchangeable occlusal tables.

Harmony between static centric occlusion and centric relation was obtained by means of grinding. The abutment teeth were prepared for occlusal rests. Maxillary and mandibular impressions were made and poured in artificial stone. The maxillary cast was mounted on a Hanau Model H articulator, using the face-bow transfer method. Intraoral wax interocclusal records were made in the centric relation, and the mandibular cast was mounted. Average readings, obtained from four interocclusal protrusive wax records, were used in setting the condylar guidances. The incisal guidance was set in accordance to the dictates of the anterior teeth. The lateral condylar guidances were set in accordance with the Hanau formula.

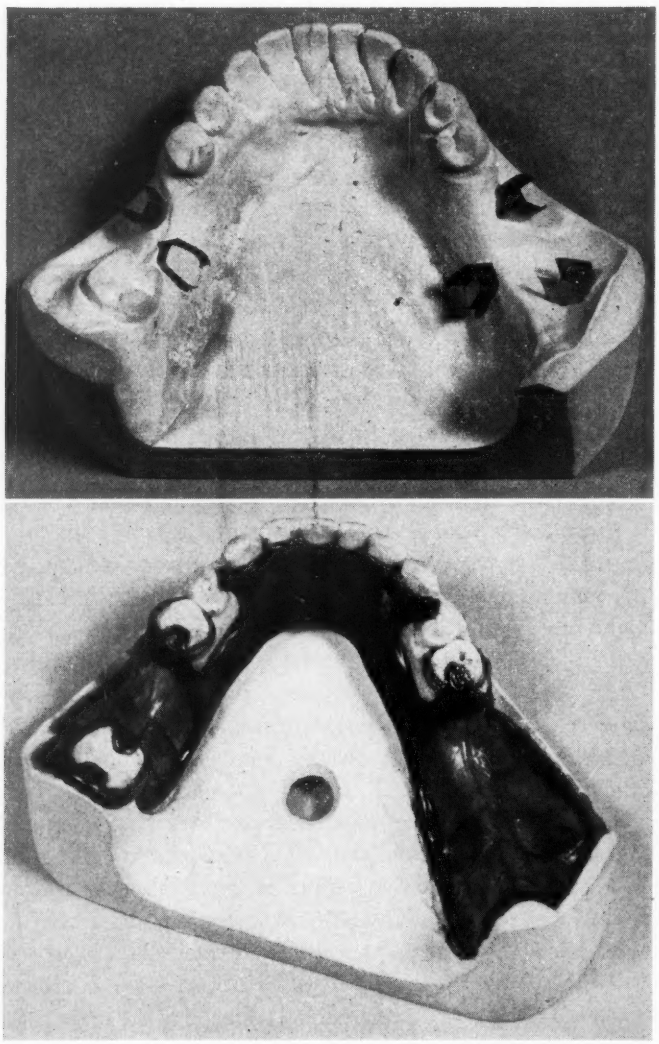
Two partial dentures of similar design were fabricated. One was used as a service partial denture. It was worn for two months, prior to any testing procedures, to accustom the patient in the wearing of a prosthetic appliance, and to attain the maximum masticatory efficiency as suggested by Abel and Manly.[4] The other, a gold test partial denture, was fabricated to determine the effect of various partial denture designs on the distribution of force upon the supporting tissues.

The design of the gold test partial denture included the use of a ring-type clasp with a buccal reinforcing arm on the left second molar, a circumferential type clasp on the left second bicuspid, a bar type clasp (T) on the right second bicuspid, a lingual plate connecting wide denture bases, and mesio-occlusal rests as indirect retainers on both first bicuspids. Five isolated springboards were incorporated in the gold denture base to serve as measuring sites for the reception of Baldwin SR-4 type strain gauges. The springboards were designed in the gold denture base in a manner as suggested by Frechette.[5] The springboards were 7 mm. in length, with the attached ends directed inward to make the base 4 mm. in width (Fig. 1). This design was adopted to reduce artifact responses to the strain gauges. On the right side (the free-end base side), the springboards were located in widely separated areas buccally, lingually, and distobuccally; on the left side (the tooth-borne side), the springboards were located bucally and lingually.

Interchangeable occlusal sections were fabricated in a manner as suggested by Frechette,[5] Trapozzano, and Lazzari.[6] The gold reinforced interchangeable sections were designed for a large occlusal table and a relatively small occlusal table, using Trubyte New Hue 33° posteriors, molds 34M and 28M, respectively (Fig. 2). Interchange of the sections was accurate and easily performed. The sections, after positioning, were made secure by means of screws.

Occlusal corrections of the interchangeable occlusal tables were made on the articulator to remove any processing errors. The result was a test partial denture, with a gold denture base, upon which interchangeable occlusal tables could be placed easily and accurately.

A.



B.

Fig. 1.—*A*, The refractory investment cast with stainless steel inserts in place in order to create in the denture base isolated springboards to be used as measuring sites. B, The wax up completed.

Five Baldwin SR-4 type strain gauges were cemented into place upon the five isolated springboards. The gauges were rendered waterproof by means of suitable adhesives. The electronic circuitry consisted of a standard Wheatstone bridge, with amplifiers and a multichannel Brush recorder to amplify and record

the pressures exerted upon the supporting tissues (Fig. 3). Compensating gauges were used to provide the necessary balance in the circuitry. Since a springboard is in close adaptation to the supporting tissues, any deformation of it induced by the forces of mastication would cause a deformation of the high resistance grid of the strain gauge, which, in turn, would vary the amount of resistance and disturb the sensitive electronic balance, which could then be amplified and recorded.

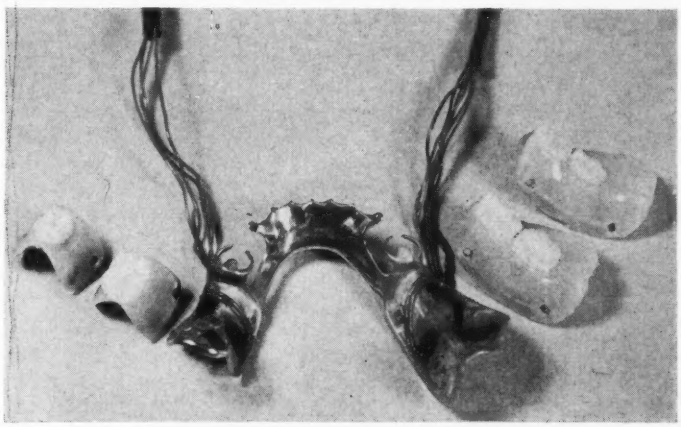


Fig. 2.—The test partial denture used in the studies with the interchangeable occlusal sections.

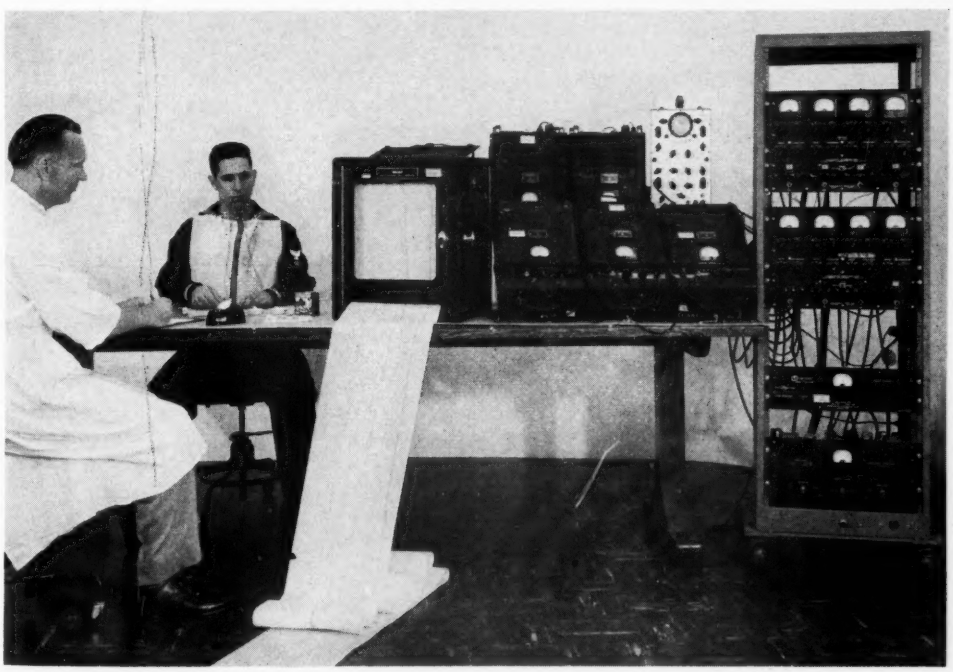


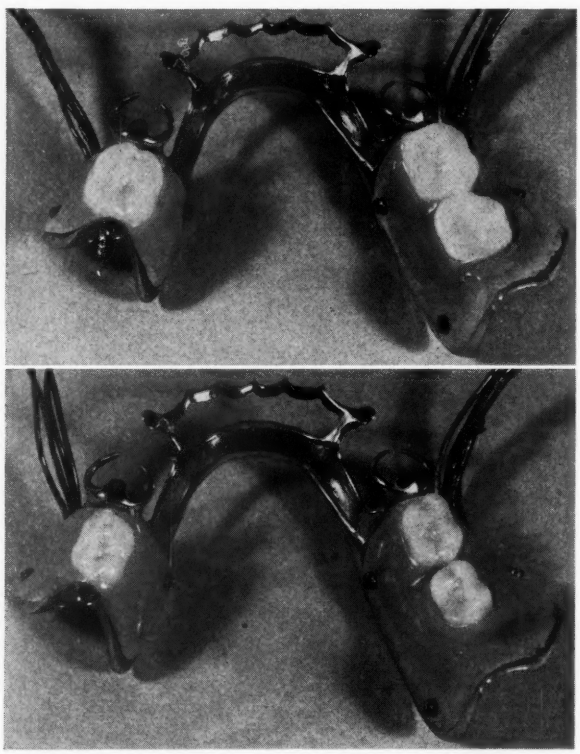
Fig. 3.—The patient and the electronic testing equipment used in the studies.

The calibration of each springboard was accomplished in a manner similar to that described by Frechette.[5] Only positive deflections were measured and recorded. Negative deflections were noted as to their occurrence and location.

The series of partial denture designs studied were as follows:

1. The test denture as it was designed originally.
2. The reinforced buccal arm was removed from the ring clasp.
3. The ring clasp was removed.
4. The lingual plate was altered to become a continuous bar retainer (Fig. 4).
5. The continuous bar retainer was removed (Fig. 5).
6. The indirect retainers were removed.
7. The rigid lingual bar was reduced so it would be a flexible bar (Fig. 6).

A.



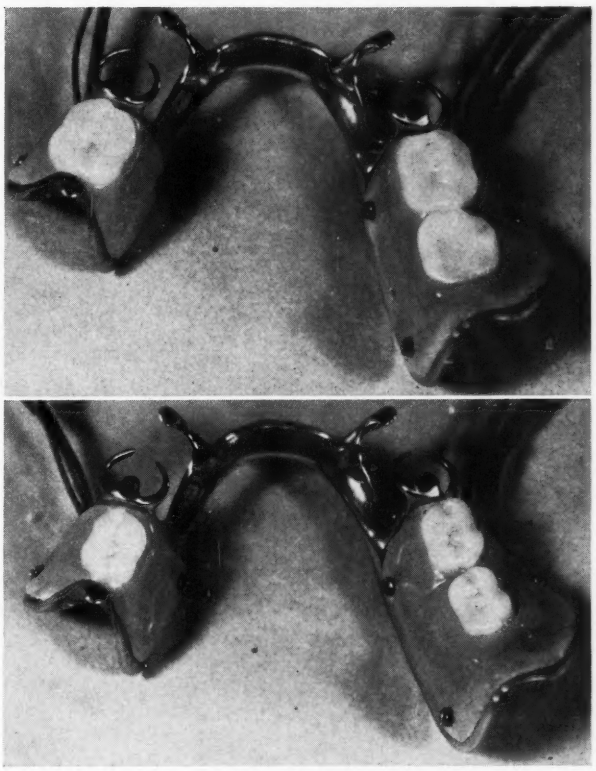
B.

Fig. 4.—*A*, The lingual plate was altered to become a continuous bar retainer. The large occlusal table is in position. *B*, The same partial denture design as in *A*, except the small occlusal table is in position.

TESTING PROCEDURES

The test food used in the studies was peanuts (cocktail, salted). With the electronic circuitry in balance, and the large occlusal table in position and secured, the patient was given a 3 gram portion of peanuts and was instructed to place and chew the peanuts on the left side of his mouth, his preferred side. The recorder recorded five simultaneous tracings in the form of deflections produced by pressures at the springboards (Fig. 7). The procedure was done for the right side of the mouth and also for random chewing. This procedure was repeated

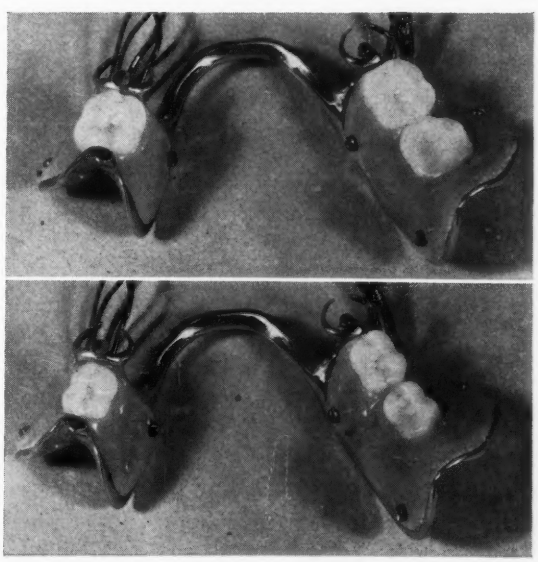
A.



B.

Fig. 5.—*A*, The continuous bar retainer was removed. The large occlusal table is in position. *B*, The same partial denture design as in *A*, except the small occlusal table is in position.

A.



B.

Fig. 6.—*A*, The rigid lingual bar was reduced so it would be a flexible bar. The large occlusal table is in position. *B*, The same partial denture design as in *A*, except the small occlusal table is in position.

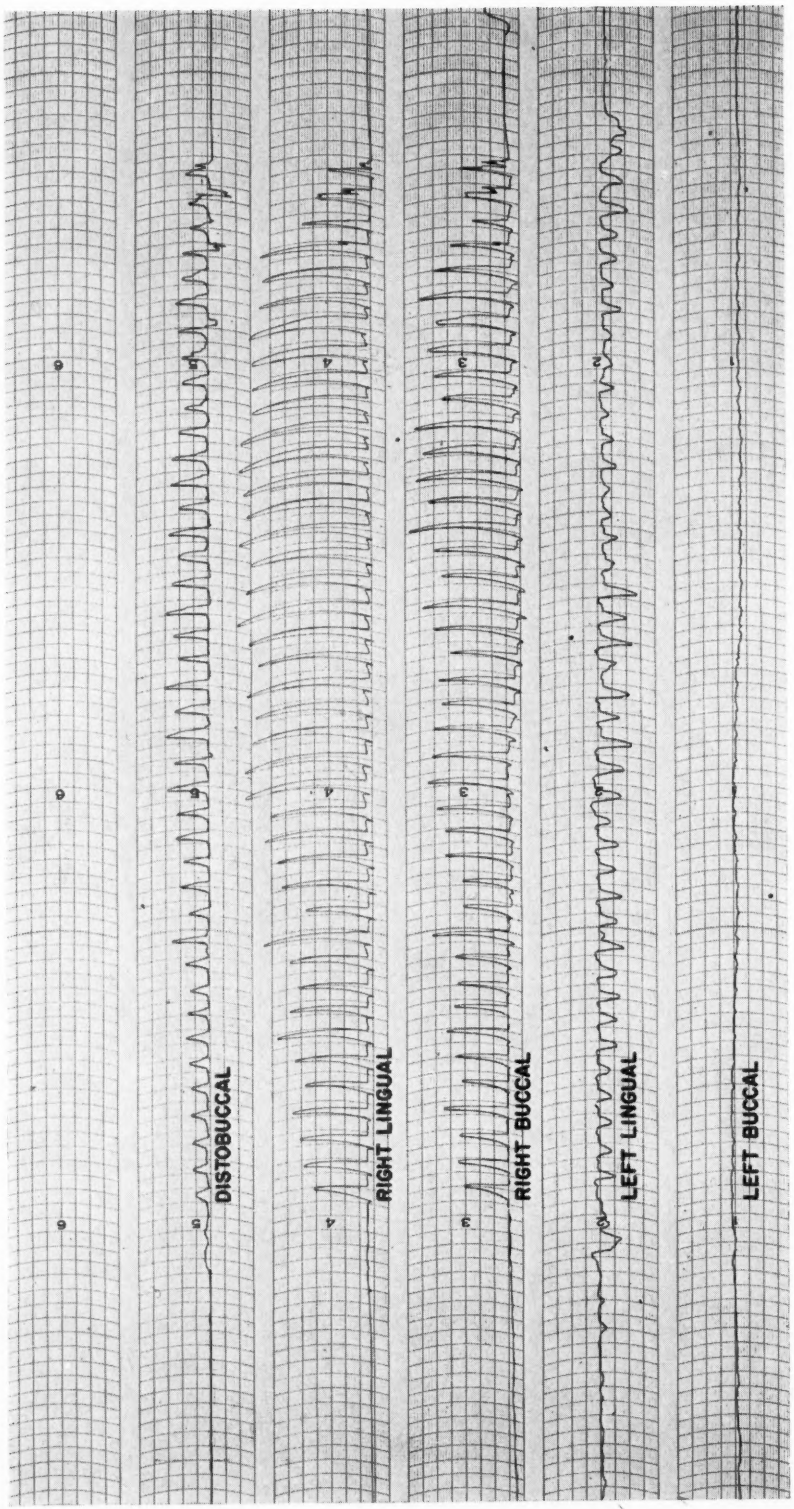


Fig. 7.—Five simultaneous recordings obtained on a Brush recorder.

until two satisfactory records were obtained for each situation. These records were then measured for the height of deflection for each chewing stroke, and the pressure per stroke was recorded. The average pressures were determined for each springboard.

The large interchangeable occlusal table was removed and replaced with the small occlusal table and the procedure repeated.

The method used to determine masticatory performance was that suggested by Yurkstas and Manly.[7] Three gram portions of peanuts were presented to the patient, who was instructed to chew the peanuts for 20 strokes on a given side of the mouth, and to expectorate the chewed particles into a beaker. This procedure was repeated with 5 portions of peanuts. The combined chewed particles were washed on a 10-mesh screen (U.S. Standard Sieve Series). Volumetric measurements were made, and the masticatory performance was computed by dividing the volume of the particles passing the 10-mesh screen by the total volume of food recovered from the mouth. The procedure was done for each side of the mouth and also for random chewing. It was performed with the large and small occlusal tables.

The partial denture was removed, modified, and replaced. The testing procedure was repeated for both force distribution and masticatory performance, with both the large and small occlusal tables. This procedure was followed for each modification, and data were compiled. The results on masticatory performance are presented in Table I.

TABLE I. MASTICATORY PERFORMANCE

	RIGHT SIDE		RANDOM		LEFT SIDE	
0.	30.16		41.33		35.29	
	Large	*Small*	*Large*	*Small*	*Large*	*Small*
1.	72.73	67.85	68.95	64.29	64.15	61.54
2.	71.43	62.96	68.97	60.71	66.67	63.79
3.	65.52	63.16	72.54	69.23	62.50	59.38
4.	65.45	63.64	66.67	63.64	67.65	58.73
5.	66.44	62.80	68.13	63.14	67.06	58.36
6.	69.23	61.11	70.97	65.63	66.67	57.58
7.	68.42	60.71	72.74	64.62	63.93	62.16

0, The masticatory performance that was computed with the remaining natural dentition. 1, The test denture as it was designed originally. 2, The reinforced buccal arm was removed from the ring clasp. 3, The ring clasp was removed. 4, The lingual plate was altered to become a continuous bar retainer. 5, The continuous bar retainer was removed. 6, The indirect retainers were removed. 7, The rigid lingual bar was reduced so it would be a flexible bar.

GENERAL OBSERVATIONS

The deflections produced by the masticatory pressures were recorded on a Brush recorder. The reaction of a particular springboard to a given situation was either to produce positive deflections, to remain passive, or to produce negative deflections, or a combination of positive-negative deflections. Only the positive deflections were measured and recorded, including the positive aspect of the positive-negative deflections. The negative deflections were interpreted as occurring under forces of adhesion and interfacial surface tension between the springboard and the supporting tissues.

The deflections were fairly regular and followed a rhythmic pattern. By counting the number of deflections, it was possible to determine the number of strokes it took to masticate the given amount of peanuts. It was found that with the large occlusal table, including all modifications, it took an average of 47.77 strokes on the right side; 44.69 strokes on the left side; 43.00 strokes with the patient chewing at random. With the small occlusal table, including all modifications, it took 44.92 strokes on the right side; 44.00 strokes on the left side; 41.58 strokes with the patient chewing at random. The time to accomplish the mastication ranged from 12 to 15 seconds, irrespective of the side used.

The patient expressed the opinion that he was able to masticate the prescribed quantity of peanuts with the larger occlusal table better, "I could do the job quicker." He also commented on the "springiness" of the partial denture at the final modification. Occasionally, the patient experienced difficulty in masticating the peanuts and interrupted the regular, rhythmic pattern of chewing because peanut particles became lodged in the wires emerging from the partial denture.

All modifications to the partial denture for these comparative studies could be valid only when the modification under consideration was compared to the previous modification.

SUMMARY OF FINDINGS

The average pressures derived from each of the strain gauges for the various partial denture designs were recorded under conditions in which (1) a large occlusal table, and (2) a small occlusal table were used, and with the patient chewing on the (a) left side, (b) right side, and (c) at random (Fig. 8).

1. *Large Occlusal Table.*—

a. *Chewing on the left side* (tooth-borne side): The pressures at the left buccal gauge were relatively constant for all the modifications. The left lingual gauge manifested a reduction in all positive pressures, and exhibited increased positive-negative type of deflections, indicating a pulling away of the left lingual flange from the supporting tissues. The right lingual gauge was relatively constant with small valued positive pressures. The right buccal gauge was passive, except in the final two stages of modification, in which positive pressures were obtained. The pressures at the distobuccal gauge were nonrecordable, except for the final two modifications in which positive-negative deflections were obtained.

b. *Chewing on the right side* (free-end side): The positive pressures at the left buccal gauge became less positive with each modication. The left lingual gauge, except for the initial designs, were essentially negative in nature. The initial recordings were of the positive-negative type. The right lingual gauge evidenced increased pressures upon the removal of the reinforced buccal arm of the ring clasp. Following the removal of the ring clasp, the pressures were constant and positive in nature. The right buccal gauge exhibited positive-negative pressures that were similar in magnitude, except in the final two modifications in which the pressures were markedly increased. The pressures at the distobuccal gauge evidenced increased pressures for each modification.

c. *Chewing at random:* The pressures, at all gauges, presented wide variations as evidenced by the varied height of deflections as recorded on the recorder.

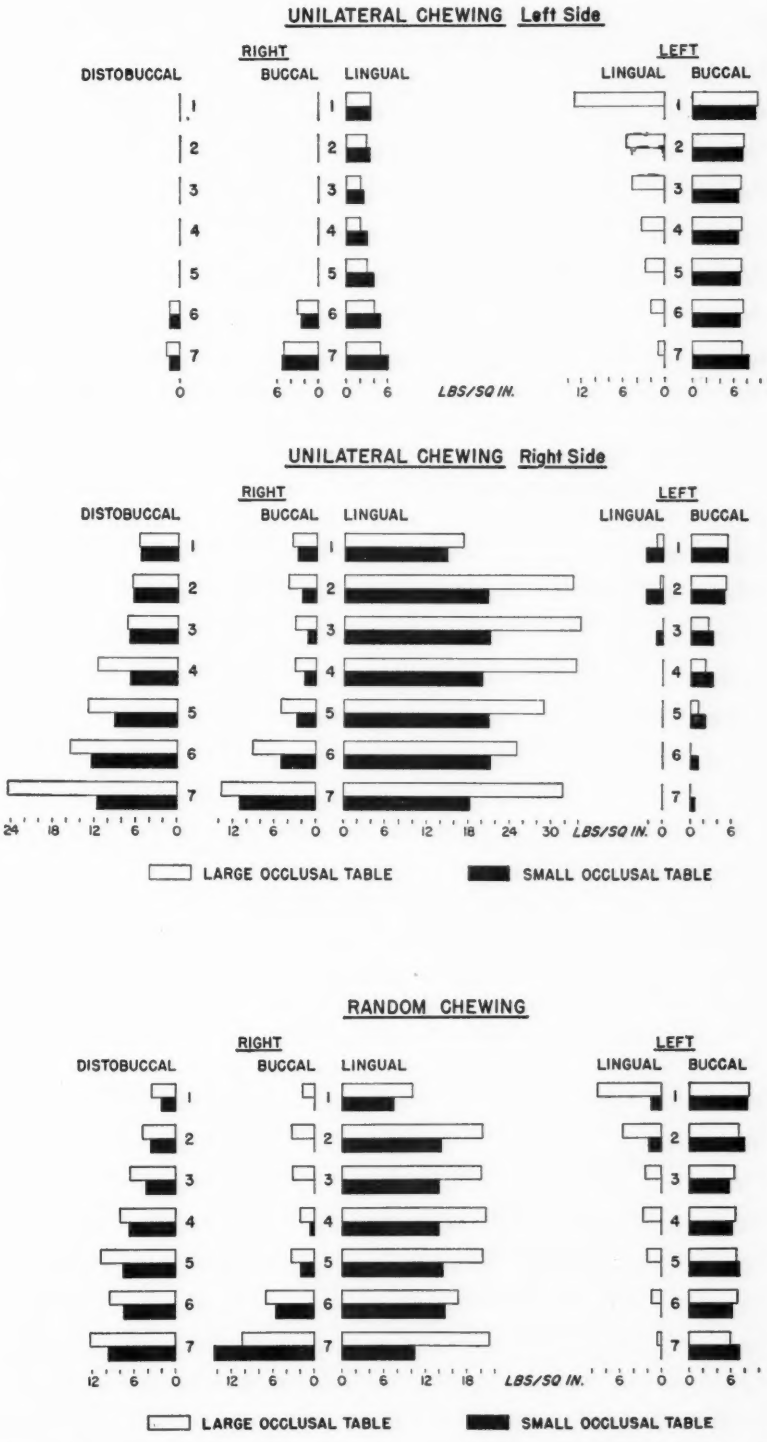


Fig. 8.—The average pressures that were recorded at the measuring sites in the study to determine the effect of partial denture design on force distribution.

These variations were due to the location of the bolus of food during mastication. The average pressures at the left buccal gauge were found to be relatively constant. The left lingual gauge initially manifested the combination type of positive-negative deflections, gradually becoming negative as the partial denture was modified to simpler designs. The right lingual gauge, except for the original design, manifested pressures that were fairly constant in their average magnitudes. They readily reflected the location of the bolus of food by high or low deflections. The pressures at the right buccal gauge exhibited positive pressures that increased with the modifications. The pressures at the distobuccal gauge reflected the pressures in a similar manner.

2. *Small Occlusal Table.—*

a. *Chewing on the left side* (tooth-borne side): The pressures at the left buccal gauge were relatively constant for all modifications and were approximately of the same magnitude when compared with the pressures obtained when the large occlusal table was used. The left lingual gauge manifested negative recordings from the very outset, and no recordable pressures could be measured throughout all the modifications. The recordings from the right lingual gauge were relatively constant and rendered small positive pressures similar to those when the large occlusal table was used. The right buccal gauge was passive with no recordable pressures, except in the final two modifications, in which positive pressures were obtained, similar to those when the large occlusal table was used. The pressures at the distobuccal gauge were nonrecordable, except in the final two modifications in which positive-negative deflections were obtained.

b. *Chewing on the right side* (free-end side): The pressures at the left buccal gauge were positive and similar to those obtained when the large occlusal table was used. The pressures at the left lingual gauge, except for the initial designs, were negative in nature. In the initial designs, the deflections were of the positive-negative type, similar to those when the large occlusal table was used. The right lingual gauge produced positive pressures that were relatively constant. The pressures were from 15 to 44 per cent smaller than those obtained when the large occlusal table was used. The pressures at the right buccal gauge were from 22 to 66 per cent smaller than those when the large occlusal table was used. The greatest pressures were obtained in the final modification, although smaller when compared to the pressures obtained when the large occlusal table was used. The distobuccal gauge evidenced progressively increased pressures with each modification. Increased positive pressures were particularly noted in the final two modifications. Pressures were found to be from 2 to 62 per cent smaller than those when the large occlusal table was used.

c. *Chewing at random:* The left buccal gauge evidenced variations in the height of deflections depending upon the location of the bolus of food. Average pressures were fairly constant for all the modifications, similar to those found when the large occlusal table was used. The deflections at the left lingual gauge initially were of the positive-negative type. With subsequent modifications, the deflections became almost entirely negative and nonrecordable. The pressures at the right lingual gauge were fairly constant in their average magnitudes, but smaller than those obtained with the large occlusal table. The pressures obtained

at the right buccal gauge were initially nonrecordable. However, as the modifications progressed, positive pressures were obtained. The greatest pressures were obtained in the final modification. The distobuccal gauge exhibited pressures that became progressively larger with each modification, but were smaller when compared to the pressures obtained with the large occlusal table.

CONCLUSIONS

Conclusions made on the findings in one patient are and must be presented with extreme caution.

Based on the findings of this study, it can be concluded that: (1) The reduction of the size of the occlusal table reduces the vertical and horizontal forces acting on the partial denture and lessens the stresses on the abutment teeth and supporting tissues. (2) The effect of partial denture design on masticatory performance did not reveal any significant relationship. With the patient chewing on the right side, and considering all the modifications, the reduction of the size of the occlusal table reduced the masticatory performance within a range of 3 to 12 per cent. However, this relatively small reduction of masticatory performance was more than compensated for by a *marked* reduction of pressures upon the supporting tissues. (3) The findings of the effect of partial denture design on the distribution of force upon the supporting tissues were inconclusive. Generally, it can be stated that a rigid design is more desirable than a flexible one. Specifically, a rigid lingual bar is more desirable than a flexible bar in withstanding horizontal stresses. (4) A ring clasp should be reinforced with a buccal arm to reduce its flexibility.

I wish to acknowledge indebtedness to Captain A. R. Frechette, DC, USN, for his counsel and guidance, and to J. C. Thompson, B.S., F. D. Carpenter, B.S., R. K. Logan, J. L. Eitel, E.E., and others of the U. S. Naval Electronics Laboratory, San Diego, California, for their generous suggestions and invaluable technical assistance; and to V. Hartzell, DT1, USN, of the U. S. Naval Training Center, San Diego, California, for assisting in the fabrication procedures.

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RESTORATION OF LOWER ANTERIOR TEETH

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THE REBUILDING OF LOWER anterior teeth presents both esthetic and mechanical problems. The incisal edges and the upper half of these teeth play a prominent part in facial appearance. The crowns are normally small. There is a minimum amount of tooth structure to protect the underlying pulps and at the same time provide retention for full crowns. When full coverage is indicated for the lower incisors, there is a choice among the all-porcelain jacket shoulder crown, the porcelain jacket crown with a gold shoulder, and the gold crown with porcelain or acrylic resin veneer.

THE ALL-PORCELAIN JACKET SHOULDER CROWN

The all-porcelain jacket shoulder crown is the ideal restoration (Fig. 1). It has been successfully tested for over half a century with little change, though both the porcelain and the technique employed have been improved.

The preparation of the teeth was simplified with the introduction of the diamond instruments. The disc and cylinder shapes are popular and are used mostly with a straight handpiece. The substitution, many years ago, of Novocain for cocaine, as a local anesthetic, was a boon that few present-day dentists can appreciate. With the advent of Novocain came the mandibular injection. This not only eliminates the pain of preparation of the lower incisors, but also allows the muscles of the lower lip to relax.

The size and location of the pulp as shown by roentgenograms must be carefully considered. A minimum of tooth structure is cut away to secure an accurate and complete shoulder all around and just below the gingival margin. An incisal clearance of somewhat more than a millimeter should be provided for the necessary bulk of porcelain. In some instances, a lower anterior may be so worn that the incisal edge is several times its original dimension. In the preparation, the tooth should be reduced so that the porcelain jacket may restore the normal tooth anatomy.

Before the introduction of methyl methacrylate resin, it was difficult to provide a satisfactory temporary crown for lower incisors. The celluloid forms in

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Read before The Greater New York Academy of Prosthodontics, New York, N. Y., Dec. 4, 1955.

Received for publication Jan. 26, 1956.

use were difficult to adapt. An acrylic resin crown can be made speedily and seated with a medicinal cement. The result is a natural-appearing temporary covering for the tooth, with proper protection to the pulp and to the gingival tissues, until the permanent restoration is ready.

The occlusion of the lower incisor porcelain jacket crowns receives more attention now than formerly. It is not always possible to grind the opposing upper anterior teeth to shorten them. In such cases, it may be difficult to secure an ideal functional result. However, if the lower incisors are found to be in occlusion when the jaws are in centric relation, this contact must be maintained when the jacket crowns are cemented or the teeth will extrude later and interfere with function.

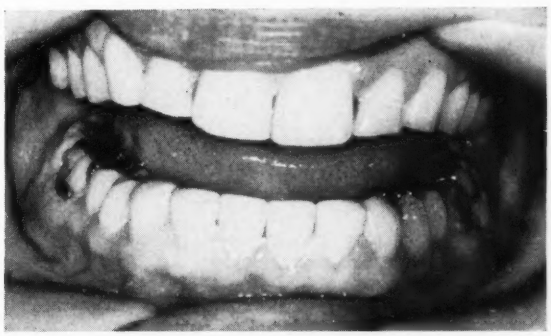

Fig. 1.—All-porcelain jacket shoulder crowns on lower incisors.

The introduction of transparent porcelain, some twenty years ago, was a step forward in esthetics. It is desirable to know what the exact arrangement of the transparent porcelain will be in the completed jacket. This can be accomplished by first building and biscuiting the cervical and middle third high-fusing porcelains. This biscuited porcelain is then ground away, where necessary, and replaced with transparent porcelain. The latter is added at the second biscuit bake at the same time that cervical porcelain is filled into the ditch at the gingival margin. In most instances, pink porcelain stain should be glazed on the surface of the cervical fourth of the jacket crowns. The purpose of this stain is to imitate the reflection of pink from the lips and the surrounding gingival tissues. This reflection is apparent on the surfaces of the adjoining natural teeth, but not on the porcelain of the jacket crown. Without a stain of this color, the jacket lacks a lifelike appearance. The pink and any other high-fusing stains are added to the surface of the biscuited jacket crown and glazed with it. If it is found necessary, medium-fusing pink stain can be applied after the jacket crown has been glazed.

THE PORCELAIN JACKET CROWN WITH A GOLD SHOULDER

The porcelain jacket crown with a gold shoulder (Fig. 2) is indicated for lower anterior teeth where the necks of the teeth are so constricted or so weakened by dental caries that a shoulderless preparation is preferable. This permits a minimum reduction of tooth structure and the maximum protection of the underlying

pulp. It also eliminates the danger of the natural tooth breaking horizontally as it might if a shoulder preparation were made. Although this is an infrequent occurrence, the pulp would invariably be involved.

About thirty-five years ago, LeGro[1] introduced the all-porcelain jacket shoulderless crown to eliminate the cutting of a shoulder in the natural tooth. The crown failed because of the impossibility of securing a proper fit between the porcelain and the tooth. Also, the thin porcelain resulted in crescentic fractures on the labial and lingual cervical areas. When a shoulderless preparation is decided upon, a gold casting should be used to supply the fit, strength, and contour between the porcelain jacket shoulder crown and the prepared tooth at the gingival margin (Fig. 3).

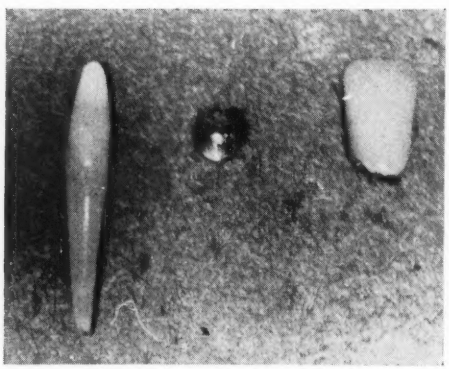

Fig. 2.—A lower incisor with a shoulderless preparation. A gold shoulder and a porcelain jacket shoulder crown.

Fig. 3.—Porcelain jacket shoulder crowns with contoured gold shoulders. The gold shoulders are beveled on the labial surface and are completely hidden by the free gum margin.

The preparation of the tooth requires that all contour be removed to a distance of about a millimeter below the gingival margin. The tooth must be somewhat cone-shaped and shortened to provide for a sufficient bulk of porcelain on all aspects. The preparation is accomplished with various diamond discs and with the diamond cylinders as suggested by Smith.[2]

THE GOLD CROWN WITH THE PORCELAIN VENEER

The gold crown with the porcelain veneer has been used more or less unsuccessfully for many years. Its disadvantage for a lower incisor is the necessity of a

heavy gold incisal tip to protect the porcelain from fracture or displacement. When this happens, a permanent repair is difficult because a repetition is probable.

THE GOLD CROWN WITH AN ACRYLIC RESIN VENEER

The gold crown with an acrylic resin veneer is indicated where the position of the pulp prevents the removal of sufficient tooth structure to provide adequate space for a porcelain incisal edge. If the teeth are firmly implanted and functional occlusion is severe, a substantial gold incisal edge must be in evidence as it is needed to prevent the wearing away of the acrylic resin. A gold incisal edge on a lower anterior tooth presents a problem in esthetics. At the same time, particularly with older patients, appearance may not be so important. If the functional occlusion is mild or absent, the acrylic resin can be extended to the incisal edge and hide the gold somewhat.

Methyl methacrylate with its shortcomings recognized has thus taken a place in the rebuilding of lower incisors. Reliance must be placed upon gold reinforcement on the incisal edge to withstand functional occlusion and upon a gold framework to make cementation permanent. The metal is a severe handicap in efforts to secure a pleasing esthetic result.

The preparation of the tooth is a combination of shoulder and shoulderless techniques. On the labial surface and labial angles a shoulder is cut to provide space for retention of the acrylic resin in the gold and to allow for the correct shaping of the labial veneer. The remainder of the preparation is shoulderless. The acrylic resin must be securely anchored in the gold to control the expansion and contraction of the material with temperature changes in the mouth; otherwise debris will accumulate between the gold and the acrylic resin veneer and show as a discoloration through the acrylic resin.

Fig. 4.—These lower anterior teeth are splinted by means of a gold framework to which individual porcelain jacket shoulder crowns are cemented.

SPLINTING OF LOOSE LOWER ANTERIOR TEETH

Splinting of loose lower anterior teeth with full coverage is more practical than with gold inlays. If the natural crowns are longer than average, porcelain jackets on a gold framework may be employed (Fig. 4). The gold is extended

interproximally towards the incisal edge to provide a contact point for the soldering together of the individual units without impinging on the interproximal soft tissues. The metal can be hidden by the porcelain and a favorable esthetic result secured.

If the lower incisor crowns are short, gold crowns with acrylic resin veneers are used. The metal is extended to the incisal edge. The individual crowns, regardless of their length, can thus be joined together without interference with the gingival tissues. In the case of loose teeth, the gold incisal edge can be somewhat hidden by the acrylic resin because, with the mobility of the teeth, there is less danger of functional wear. However, the splint does not have the favorable esthetic result possible with porcelain jacket crowns.

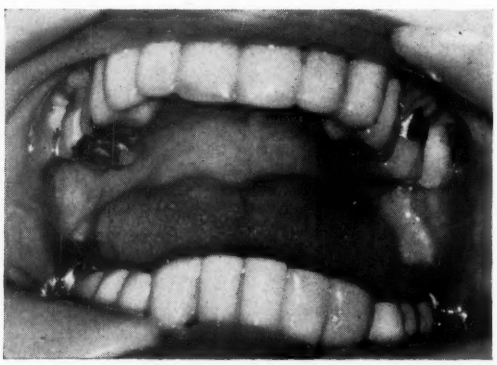

Fig. 5.—A fixed partial denture in the lower jaw extending from the right molar to the left cuspid. The right cuspid and right central are porcelain pontics. The left central, lateral, and cuspid are used as abutments with porcelain jacket crowns cemented to a gold framework.

Fig. 6.—Gold thimble crowns on the lower right cuspid and left first bicuspid. The thimble crowns contain the female parts of the precision attachments. Partial porcelain jacket crowns are cemented to the gold thimbles.

Lower incisors are usually unsatisfactory as abutments for fixed partial dentures. The roots are small and the supporting alveolus is of delicate structure. These teeth are frequently the last to be lost. Occasionally through accident or otherwise, lower anterior teeth are found to be missing, and can be restored with fixed or removable partial dentures. The most practical type utilizes three-quarter

gold inlays in the cuspids and Steele facings as pontics. If esthetics are important, porcelain jacket crowns as abutments and porcelain tube teeth as pontics, all assembled on a gold framework, are employed (Fig 5).

With an extensive loss of alveolar structure, a removable precision partial denture is indicated. Gold inlays or porcelain jacket crowns on gold thimbles are used for the cuspid abutments. Porcelain pontics are supplied on a metal base with acrylic resin to restore the missing soft tissue contours (Fig. 6).

CONCLUSION

Quite recently the claim has been made that with a porcelain fused to gold by the process advocated, breakage is practically eliminated. A certain percentage of breakage has always been considered inevitable with any porcelain. Dental porcelain restorations should be designed so that breakage can be readily and substantially repaired. Up to the present time, no better full coverage for lower incisors than the all-porcelain jacket shoulder crown has been found.

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22 Central Park South
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ACRYLIC RESIN VENEER CROWN BY THE DIRECT METHOD

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WITH THE TREND TOWARD full coverage, the full cast crown, either veneer or all gold, is now the most popular type of abutment for fixed and removable partial dentures. It is also the most commonly used restorative method where, in the past, multiple surface inlays or ¾ crowns were employed.

The indirect method of fabrication is utilized frequently by the average dentist, but one must be aware of a number of shortcomings of this procedure. These can be eliminated by the direct technique, which has the following advantages:

1. Time element: The entire procedure can be accomplished in a short time in a dental office, thus eliminating time lapse necessary to complete the indirect procedure in a commercial laboratory.
2. Economy: The only expense involved is the cost of the gold, as there are no laboratory charges.
3. Casts: No dies or casts are necessary, since the patient is the articulated model.

PREPARATION OF THE TOOTH

The preparation may be shoulderless for the posterior teeth, but a good shoulder on the labial surface is desirable on anterior teeth. The preparation is carried below the free margin of the gingiva, with a slight bevel for finishing at the shoulder. Adequate reduction of the tooth is essential. The proper color in a veneer depends to a high degree on the bulk of plastic in the veneer. If the proper reduction of the tooth is not obtained, a poor color will result.

SELECTION OF THE BAND AND IMPRESSION TECHNIQUE

1. A copper band, approximately two sizes larger than the circumference of the tooth, is selected.

2. The band is contoured to follow the gingival termination of the preparation and, in general, to approximate the gingival margin of the preparation.

3. The band is annealed by plunging it while red hot into either water or alcohol to remove all tension. Then, by means of a Peeso pliers (No. 118), the gingival portion of the band is bent in to contact the tooth subgingivally on all

Received for publication Jan. 14, 1956.

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surfaces. This procedure (Fig. 1) makes the oversized band fit the tooth closely, and supplies the space necessary for the bulk of wax required for contouring and carving.

In our opinion, this step is the most important in the entire technique. A properly fitted and contoured band simplifies the procedure and still affords the highest degree of accuracy.

4. The band is filled with softened blue inlay wax, the impression is made, chilled slightly, and removed.

5. The impression is examined for defects in the finishing line as well as for the presence of sufficient bulk of wax throughout (Fig. 2).

6. Excess wax is then removed, and the copper band is cut part way through with a Carborundum disc, at the point of greatest bulk, and the cut is completed with a sharp surgical blade No. 11 (Figs. 3 and 4). The band is removed (Fig. 5). Wet cotton is inserted into the impression, as a precautionary measure, to conduct the heat away from the wax while the band is being cut (Fig. 3).

7. The wax impression is trimmed to the finishing line. The carving of the wax pattern is then completed in the hand, and finished to the final form and full contour in the mouth (Fig. 6). A removal nodule is placed on the lingual surface.

8. The final wax pattern is invested by carefully painting the inside of the pattern and filling it with Cristobalite investment. It is embedded in a mound of the Cristobalite investment so that the entire labial or buccal and proximal surfaces are exposed. When it is set, the Cristobalite investment is trimmed so that it will fit into the regular size inlay ring (Fig. 7).

9. The window is cut out in the wax, a sharp blade and any other carving instrument being used. Extension for esthetics should be considered at this point. The depth of the window is determined by the thickness of the wax on the labial surface, and the wax should be cut until it is fairly transparent (Fig. 8). Where thickness permits, the wax around the window is undercut for retention.

10. Several methods may be used for providing retention for the veneer. The most popular involves the use of gold loops at the proximal and incisal margins of the window. These wire loops can be obtained ready-made, or they can be made of 28 gauge gold wire. The loops are heated and inserted into the wax where the acrylic resin will be thickest (Fig. 9).

11. The lingual or occlusal Cristobalite investment is trimmed away for the reception of the sprue. The wax pattern is sprued at the incisal edge or occlusal surface. The sprue is secured to the pattern with wax for extra strength. The partially invested, sprued pattern is immersed in cold water for two minutes before its investment is completed (Fig. 10).

12. The pattern is carefully painted with Cristobalite investment and inserted into the inlay ring without vibrating it, since one of the dangers is the separation of the pattern from the sprue, which would result invariably from vibration. The casting is made in the usual manner.

13. The button is removed, and the crown is trimmed and polished for a try-in. If, at this point, it is found that the gold is too conspicuous for esthetics,

Fig. 1.

Fig. 2.

Fig. 3.

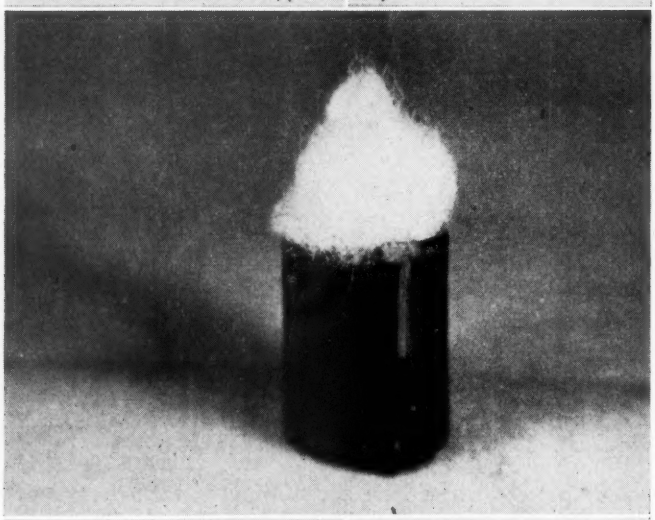

Fig. 4.

Fig. 5.

Fig. 1.—The copper band is contoured, annealed, and bent in at the gingival end.

Fig. 2.—The completed impression in wax in the copper band.

Fig. 3.—The band is cut for the removal of the impression. Note the wet cotton which prevents distortion from the heat developed in making the cut.

Fig. 4.—The copper band is partially removed.

Fig. 5.—The wax impression removed from the copper band.

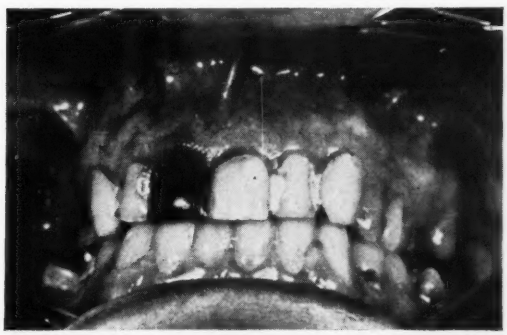

Fig. 6.—The complete wax-up of the full crown in the mouth.

Fig. 7. Fig. 8.

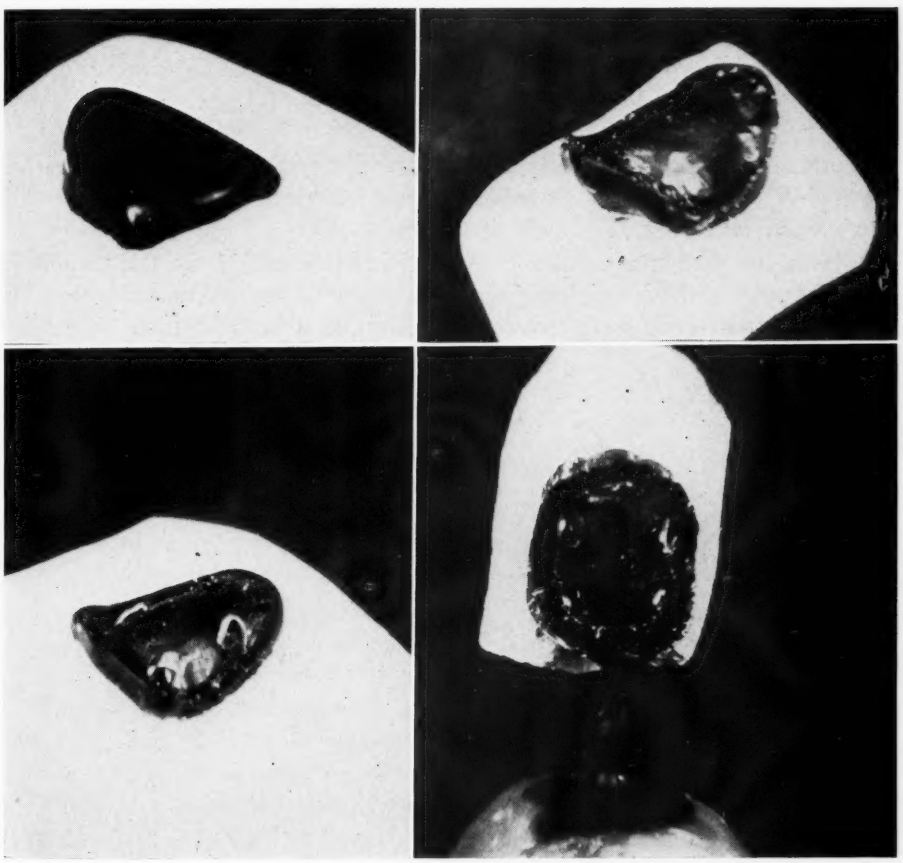

Fig. 9. Fig. 10.

Fig. 7.—The impression is partially invested with the labial surface exposed.
Fig. 8.—The window is cut out in the wax for the insertion of the acrylic resin veneer. Note the thin layer of wax which remains.
Fig. 9.—Gold loops are inserted for retention of the acrylic resin.
Fig. 10.—The sprued pattern. Note the reinforced attachment of the sprue.

the window can be enlarged with a sharp cross-cut fissure bur. Then the final polishing of the crown is completed (Fig. 11), and the pattern of the acrylic resin veneer is carved, packed, and processed in the usual manner.

Fig. 11.—The completed casting is fitted in the mouth.

SUMMARY

A practical method of waxing veneer crowns directly in the mouth has been described. The procedure is rewarding, from an economic as well as a technical point of view.

It gives the dentist a certain amount of independence from the commercial laboratory, and for those who carry out their own laboratory procedures it does away with the time-consuming steps required by the indirect method.

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PLATINUM-PORCELAIN RESTORATIONS

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THERE HAS NEVER BEEN any dispute as to the desirability of porcelain as a full coverage dental restoration material. It is indeed true that porcelain *was* limited to ideal or almost ideal conditions due to its fragility. This need no longer be true when porcelain is baked to a cast understructure of a platinum group alloy.

Since the inception of prosthetic dentistry, attempts have been made to simulate nature in both appearance and function. Many materials and theories have been applied to achieve these ideals, with far-reaching success. In these many concepts and applications of an abundant amount of available materials, porcelain always indicated itself as the ideal esthetic material, duplicating the natural tooth enamel in appearance. This has been realized to a lesser or greater extent for a long time.

Approximately 250 pounds per square inch of force is exerted on posterior teeth during the mastication of average food matter. The average force exerted in all parts of the mouth is approximately 100 pounds. Nature has provided us with a hard tooth enamel, combined with an understructure of dentine, that can withstand these pressures.

Tooth enamel in itself is a hard and fragile substance, easily cracked when not supported by the underlying dentine. A porcelain jacket crown, when constructed without the benefit of a metal foundation, simulates this condition, and the result is a large percentage of breakage. When a porcelain jacket crown is considered as a replacement, we must give due consideration to the attritional and other forces exerted on this restoration.

The preparation must provide sufficient support for the crown, and therefore it must be ideal. The preparation of the tooth and the design of the jacket crown must assure us that the stresses be along the long axis of the tooth.

There is a great similarity between a healthy natural tooth, with its hard enamel laminating its dentine understructure, and a jacket crown created by fusing porcelain to a cast noble alloy (Fig. 1). A porcelain restoration of this nature becomes practically indestructible for dental purposes. Due to the adhesion of the porcelain to the metal, the metal absorbs and cushions the forces exerted on

Received for publication Jan. 23, 1956.

the porcelain. This mechanical adhesion between porcelain and metal was made possible by developing materials that have the same coefficient of expansion and contraction.

The union formed between metal and porcelain is not chemical, but mechanical, and it is achieved through a molecular adhesion. To describe this type of adhesion, let us inspect what takes place during the firing process.

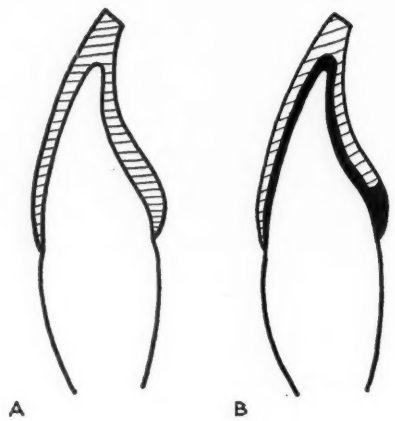


Fig. 1.—*A*, A natural tooth showing the enamel covering. *B*, A cast platinum-porcelain restoration simulating the natural tooth. The black line is the metal understructure.

Water of crystallization is drawn off at 932° F. Shrinkage and condensation of the volume of the clay substances, kaolin, feldspar, and quartz takes place at 1600°F. When the porcelain and the metal understructure reaches its maximum expansion during the baking process, the pores in the metal are greatly enlarged. Substances in the porcelain, primarily fluxing agents, become liquefied and fill the multitude of enlarged pores, and then fuse to the metal as the porcelain mass vitrifies. The porcelain, when so fused to the metal, locks itself into the crystal structure of the alloy, resulting in a strong mechanical union. If the fusing process is carried out properly, the union between the porcelain and the metal will be so great that it can be severed only by grinding, bending of the metal, or complete dissolution of the porcelain in hydrofluoric acid.

Consequently, porcelain need no longer be considered a fragile material in dentistry. Whenever a fixed appliance is indicated, porcelain can be prescribed without hesitation. For the past three years, we have used this technique for individual crowns, abutments, fixed and fixed movable restorations.* Aside from the vast improvement in strength and esthetics, there is a tremendous advantage in the design of this type of bridgework in regard to oral cleanliness and tissue compatibility.

Restorations can be splinted with contact areas at the desired height, with wide embrasures and ridge-shaped pontics. The pontics always afford porcelain

*Permadent restorations.

contact to the tissue (Fig. 2). If the resorption of the ridge tissue is anticipated, the bridge can be cemented temporarily, then relined with porcelain at a later time.

We have used precision attachments housed within porcelain crowns. These proved to be very durable and esthetic abutments. The crown can also be used in conjunction with precision rests, locks, etc. Provisions can be made in the metal for a recessed arm on the lingual surface. Occlusal rest seats can be provided for in the metal, and the crown can be so shaped to provide for desirable undercuts for clasps in accordance with a predetermined path of insertion.

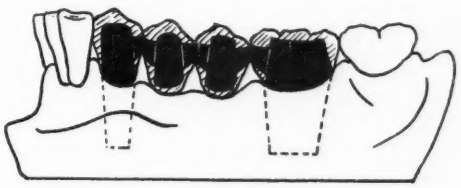


Fig. 2.—Cross section of a cast platinum-porcelain bridge showing wide embrasures, high solder joints, and glazed porcelain approximating the tissue. The shaded area is porcelain and the black area is the cast metal understructure.

THE NATURE OF THE METAL AND ITS WORKABILITY

The physical properties of the platinum group of metals are such that they magnify every defect in technique. The casting of platinum alloys requires consistently perfect technique. Platinum alloys are easily contaminated when in a molten stage. Dust in the air in a laboratory is sometimes sufficient to contaminate such an alloy during casting. This could result in a rough brittle casting, and possibly gassing when the porcelain is baked to the metal casting. The high heat necessary to melt the metal does not destroy this foreign matter which is the contaminating factor.

Properly cast, the platinum group alloy is a malleable, tough metal. This is desirable when porcelain is to be fused to it. There is always an appreciable amount of gassing of wrought platinum which will prevent adherence and mechanical union of the porcelain to the metal and can cause checking of the porcelain. This explains the high percentage of breakage during the firing or cooling when porcelain bridges were baked to wrought iridioplatinum bars. These bars, incidently, also acted as shearing devices in the bridge. The platinum group alloy used melts at about 2900° F. This enables us to bake a high-fusing porcelain to the metal understructure without introducing detrimental changes in it. Other physical properties of the metal are comparable to number 3 casting golds. This metal is lighter in weight than gold. It is comparatively rigid and can be cast with accuracy and trimmed with ease.

THE BAKING OF PORCELAIN TO METAL

Before porcelain can be baked to the metal, the metal must be prepared to make sure of a good adhesion of the porcelain. First the metal is calibrated and ground to an optimum thickness. The metal is then cleaned in an acid bath. A film of high-fusing opaque porcelain is baked over the coping. The opaque porcelain comes in various colors. Aside from blocking out the color of the metal, the opaque porcelain chosen will complement the shade of the final restoration.

The porcelain matures at 2150° F. and can be fired several times without being completely vitrified. This results in a highly glazed surface which is compatible against human teeth. It preserves the established vertical dimension because the wearing quality of porcelain is excellent and its glazed surface is less abrasive than ground surfaces.

TABLE I

RELATIVE HARDNESS OF DENTAL MATERIALS

MATERIAL	BRINELL HARDNESS NUMBER
Tooth enamel	267
Porcelain	415
Amalgam	90
24k Gold	29
22k Gold	54
Gold used for abutments	150
Acrylic resins	22-29

CAUSES FOR BREAKAGE AND REPAIRS

Nothing is indestructible; particularly that which is worn by human beings. If we can analyze and recognize the causes for fractures, we can prevent them. If we understand the behavior, performance, and limitations of the materials involved, there need be no condition given to breakage.

Since we are accustomed to working with more flexible materials, such as gold and acrylic resin, we are likely to disregard unparallelism, even after a try-in of a splint indicates it. Teeth are mobile to a degree, and metal has resiliency. These two combined will overcome more than a small degree of unparallelism of preparations. The predictable consequence will come when porcelain is baked on the metal frame. Porcelain, unlike metal or acrylic resin, has no flexibility. Where there is a condition that forces the bridge to "give" or bend in order to seat it, the porcelain will inevitably crack precisely at that point. This principle also applies to single jacket crowns. Overextension of the coping into an undercut area where it has to "spring" to place will definitely cause fracture of the porcelain. This is a rather prevalent situation with the increase in the use of elastic impression materials. In order to prevent breakage, avoid undercuts, unparallelism, and torque.

If breakage should occur after permanent cementation, the entire appliance need not be jeopardized. The metal casting is constructed very similarly to unit-built bridgework with a metal understructure supporting each unit. To make a

replacement for a fractured unit, grind the porcelain from the metal until there is enough room for a replacement. Make an impression of that particular coping and a new metal reinforced jacket crown can be made and cemented into position.

PRACTICAL APPLICATION

The operative techniques are not essentially different from other good techniques used in restorative dentistry (Fig. 3). Unlike preparations for the conventional porcelain jacket crown, *full shoulder* preparations are not necessary for this proce-

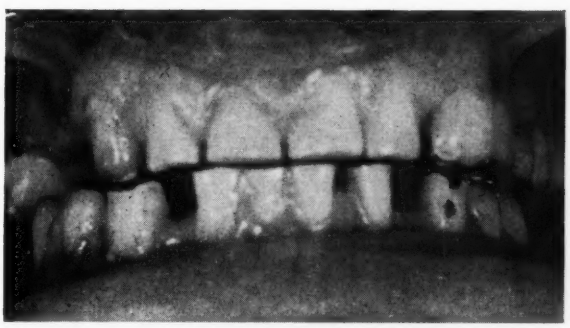


Fig. 3.—Preoperative view of the teeth to be restored.

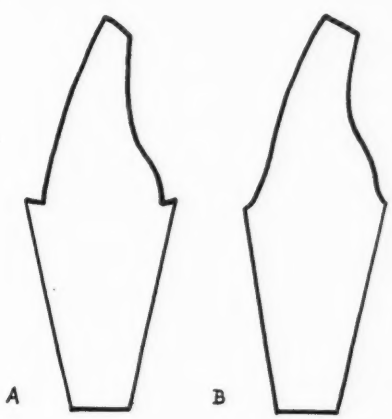


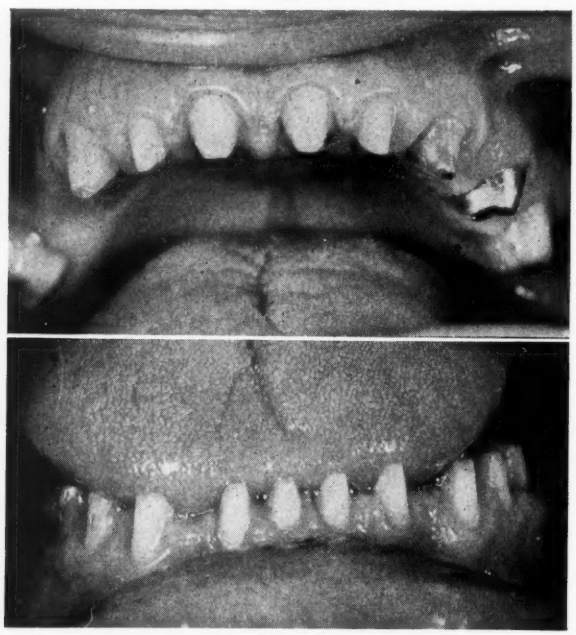
Fig. 4.—*A*, An orthodox porcelain jacket crown preparation. *B*, A platinum-porcelain preparation with the shoulders beveled.

dure. Preparations on posterior teeth are made with a buccal shoulder that connects to finishing lines on the mesial, distal, and lingual surfaces. The buccal shoulder is beveled. This will allow enough porcelain in the critical gingival area to assure color fidelity. Rather than a butt joint between the jacket and preparation, the casting should be extended to the full length of the preparation, as in full crown casting, and finished to a knife edge subgingivally (Fig. 4). The porcelain is

then carried to the finish line of metal and kept remarkably thin. If a preparation does not extend subgingivally, or if the tooth is surrounded by firm tissues, a bevel or chamfer may be indicated to reduce gingival bulk. This bevel is made at more than 90 degrees to the long axis of the tooth. The total amount of tooth structure removed will be less at the gingival margin, particularly on the lingual, mesial, and distal surfaces.

An occlusal clearance of 2.5 mm. is adequate. Where this cannot be accomplished, a metal occlusal surface may be used. Circumferentially, a provision of 1.5 mm. thickness will allow the construction of a jacket without excessive bulk. It is of utmost importance that parallelism of the abutments to each other be perfect.

A.



B.

Fig. 5.—*A*, Preparations of the upper teeth. The left second bicuspid is a gold core. *B*, The preparations of the lower teeth.

All preparations and root therapy are done under regional anesthesia (Xylocaine). Diamond stones cooled by water were used throughout. Acrylic resin splints are used as temporary coverage while treatment is in progress.

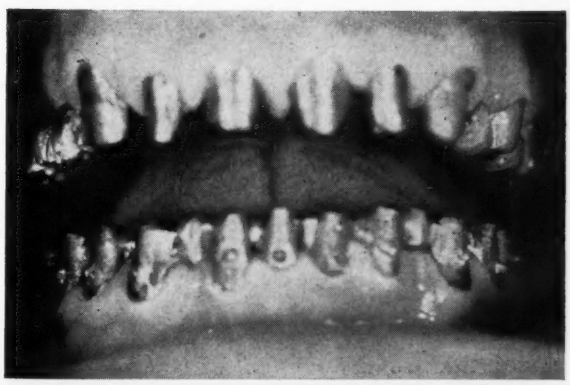
Anterior preparations are of the conventional jacket crown type with the exception that proximal shoulders are eliminated. The shoulders are made on the labial surface at the cervical margin, and then beveled to afford definite finishing lines. This allows the laboratory ample space to insure good shades at the gingival margins, eliminating excessive bulk and gray lines. Demarcation lines are made on the proximal surfaces instead of the conventional shoulder. All teeth to be splinted together are made parallel (Fig. 5).

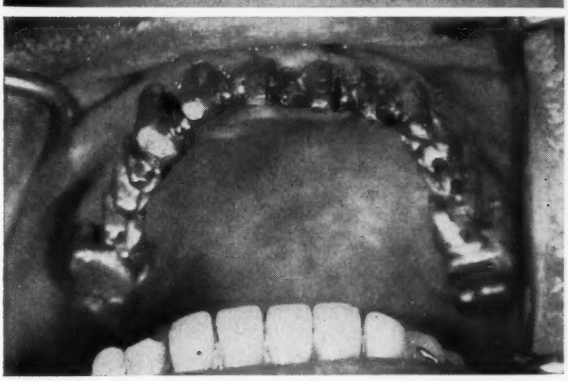
IMPRESSIONS

Any good impression technique used in bridge construction will suffice for platinum-porcelain restorations. Two techniques will meet all of the requirements. The copper band-compound impression technique is quite adequate.

The other impression technique involves the use of the new rubber base impression materials that do not change dimensionally after they are set.[1] If this material is handled properly, a fine over-all impression can be made, and subgingival areas are clearly marked and defined. The laboratory can carry a restoration to its completion on a cast made from this impression. Successful restorations can be made when either impression technique is used. The rubber base impression technique was used in the case illustrated.

A.





B.

Fig. 6.—*A*, The upper and lower copings in place. The lower copings have soldering points designed in the metal. The upper anterior teeth are not to be connected. *B*, A connected splint showing the design of the pontics in the difficult upper anterior region.

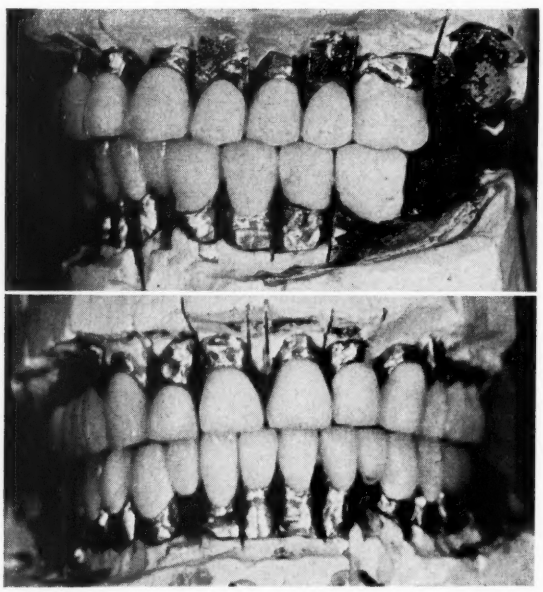
COPINGS AND CONNECTIONS

After the impressions are made, a face-bow registration, centric relation record at the determined vertical dimension, and a protrusive registration are made. The casts are mounted on a Hanau Model H articulator by means of the above registrations. Individual copings are designed and waxed with mesial,

distal, and lingual shoulders, and with connection points for subsequent soldering. The wax patterns are invested and cast. Each individual coping is tried in the mouth and checked carefully for marginal coverage, overextensions, and proper seating. The fit of the cast copings at this stage indicates the fit of the final restoration, as these are the very same copings to which the porcelain is fused later. These copings also serve as transfers for the accurate positioning of dies in the copper-band-compound technique.

All connections are made from the original model produced by the rubber impression material. This eliminates the necessity for going back to the patient for supplementary plaster impressions (Fig. 6). The various sections are splinted together.

A.



B.

Fig. 7.—*A*, The left side showing the porcelain in the biscuit bake stage. *B*, The porcelain is in the biscuit bake stage.

All connected segments are tried in the mouth and checked for: (a) bind or torque, (b) sensation of wedging of the teeth in the spans, (c) complete seating of every coping in the span, (d) marginal coverage. With all splints and copings in place, new face-bow, centric relation, vertical dimension, and protrusive registrations are made for remounting the master casts. Study casts and the color to be used are provided for the laboratory.

Fig. 8.—The completed restorations. *A*, Right side; *B*, left side; *C*, anterior view; *D*, occlusal view. Note that no metal is visible. *E*, The lower left side is complete. Note the fixed extension. The upper dies are silver-plated from a rubber impression. *F*, The lower right side is complete. Note the molar extension. *G*, Interior view of an upper right span. Glazed porcelain approximates the tissue in the edentulous areas.

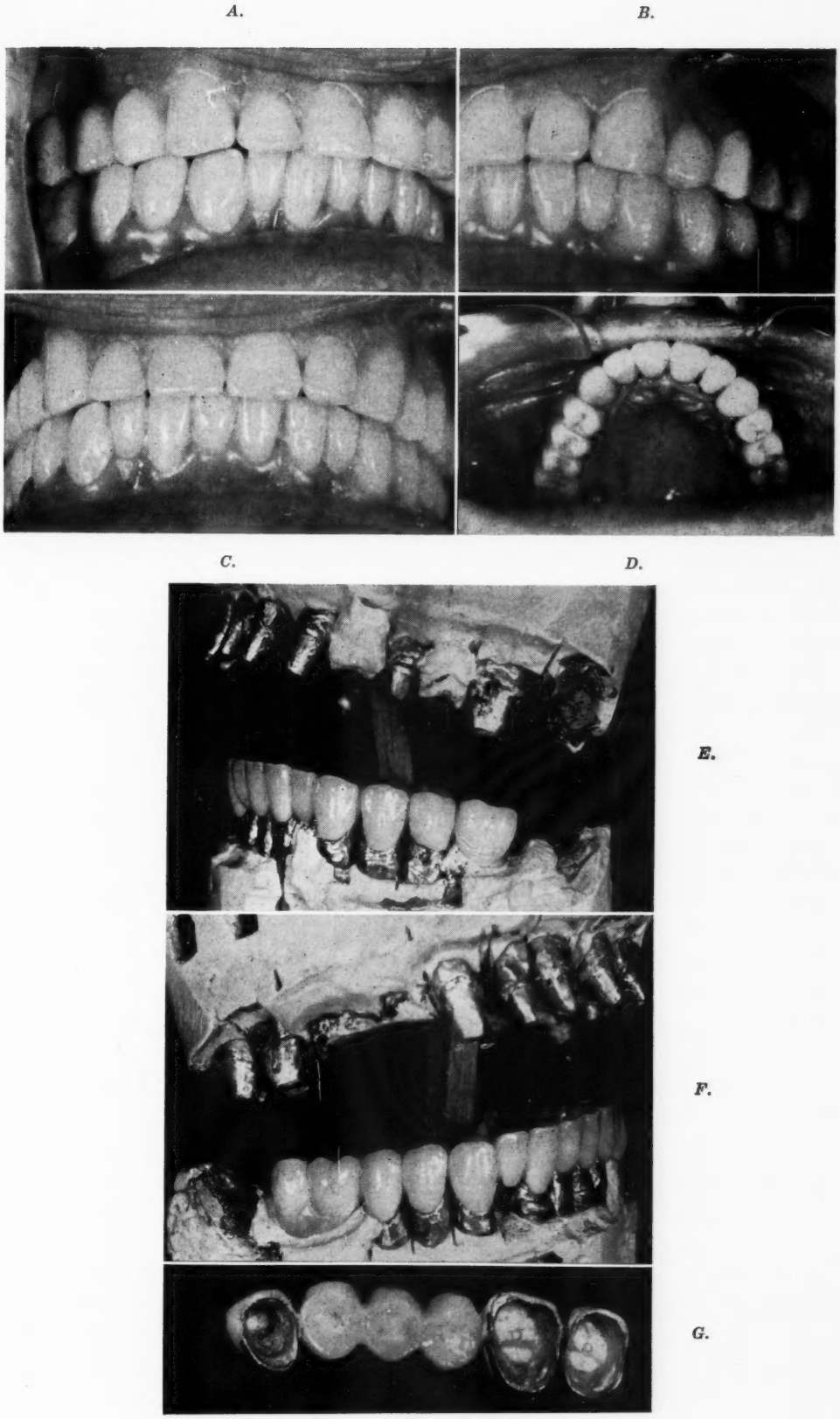


Fig. 8,*A-G.* *(For legend, see opposite page.)*

BISCUIT BAKE PORCELAIN

The laboratory returns the work complete to the biscuit bake of the porcelain. All splints and single jackets are tried in and checked for the following: (a) marginal fit, (b) binding or lack of contact between sections, (c) complete seating of spans, (d) relationship of the pontics to tissue-contacting areas, (e) centric relation, (f) impingement upon soft tissues, (g) eccentric occlusions.

All changes, esthetically or anatomically, are carefully explained and shown to the technician. Preliminary balancing of the occlusion is done for all occlusions. The restorations are returned to the laboratory for the necessary corrections. Another try-in is arranged before the porcelain is glazed (Fig. 7).

OCCLUSAL BALANCING AND CEMENTATION

The final balancing of the occlusion is done in the mouth, using two colors of articulating paper. One color is used for centric occlusion and the other for eccentric occlusions. The balance is checked at several appointments after cementation to correct minor discrepancies. The teeth are isolated, and fatty substances are removed with benzene, C.P., are cleaned with para-monochlophenol and coated with Copalite varnish. Cementation for this patient was done with a mixture made of zinc oxide, eugenol, and two drops of Ward's Tempak liquid. The patient is advised to follow a soft diet until all occlusal balancing is completed. A toothbrushing method is demonstrated and home oral hygiene care is emphasized (Fig. 8).

SUMMARY AND CONCLUSIONS

Because of its strength, versatility, and esthetic quality, porcelain baked to metal lends itself with great advantage in mouth reconstruction. The technique enables the dentist to check, reduce or increase the vertical dimension, spot and adjust the occlusion before the final glaze is put on the porcelain. Porcelain fused on metal affords the following advantages:

1. A minimum of tooth structure need be removed at the gingival margins as shoulders are not necessary. This is particularly valuable on lower anterior teeth.
2. Functional forces will not fracture porcelain with cast copings under it.
3. It retains and maintains its color, surface, and adaptable qualities indefinitely.
4. The tissue compatibility of highly glazed porcelain is excellent.
5. It is unaffected by an acid condition in the mouth.
6. The nonconductivity of the porcelain prevents thermal shock to the tooth.
7. It preserves the vitality and health of teeth; it precludes further decay.
8. The possibility of duplicating any color, characterization, and form is limited only by the ability of the ceramist.
9. Replacements can be made if a fracture does occur.
10. It is esthetically unsurpassable.

It is our belief that these materials and technique, in the hands of competent dentists and technicians, can lend themselves to wide use in restorative dentistry.

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New York 17, N. Y.

MARGINAL SEEPAGE AROUND ACRYLIC RESIN VENEERS IN GOLD CROWNS

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HEAT CURED ACRYLIC RESINS have a coefficient of linear thermal expansion of 81 p.p.m. per degree centigrade.[1,2] This would make their linear dimensional changes approximately seven times that of tooth structure and six times that of gold. The unrestricted volumetric shrinkage of the acrylic resins during curing amounts to 7 per cent. This shrinkage provides space for fluid percolation. Dimensional changes incident to the thermal effects of hot and cold beverages further provokes this problem.

Yock[3] indicates, "It is advisable, therefore, in the labial or buccal cut-out of a full gold crown prepared to receive a plastic resin, to have a complete casting protect the tooth. This gold protection may be thin but it should not be perforated."

The ever increasing demand for esthetics and retention in cast gold acrylic resin veneer crowns has resulted in a corresponding increase in cut-out perforations and veneer crowns without peripheral undercuts.[4]

The authors will present experimental evidence to confirm the existence of marginal seepage and percolation under acrylic resins of the gold acrylic resin veneer crowns.

METHOD

Cast Gold Acrylic Resin Veneer Crowns.—Twenty similar cast gold veneer crowns were made having a gingival extension about one-fourth inch long. This extension formed a collar upon which a plastic or rubber tubing could be fitted firmly and securely. Two of these crowns had no perforations in the gold window, the others were perforated in various designs as shown (Fig. 1). All of the crowns were made with Ney-Oro B-2 gold, and the retention loops with Ney Zephyr gold wire.† The gold windows were opacified with Tru-Paque, and the veneers were made with Hue-Lon‡ methyl methacrylate resin.

Microbiologic Technique.—The bacteriologic aspects of this study required the separate sterilization of the parts making up the assembly (Fig. 2).

Received for publication Feb. 2, 1956.
*Instructor, Department of Fixed Partial Prosthesis.
**Associate Professor and Chairman, Department of Microbiology.
†The gold was donated by the Ney Gold Co., Hartford, Conn.
‡The acrylic resin was donated by the L. D. Caulk Co., Milford Del.

The inner section, consisting of cotton plugged glass tubing with rubber connection, was autoclaved at 20 pounds for 20 minutes. The outer tube containing 1 per cent dextrose phenol red brain heart infusion broth was treated similarly.

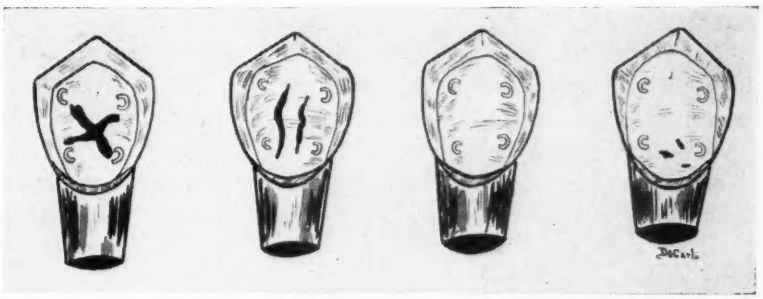

Fig. 1.—Cast gold veneer crowns, with and without window perforations and extended gold collars.

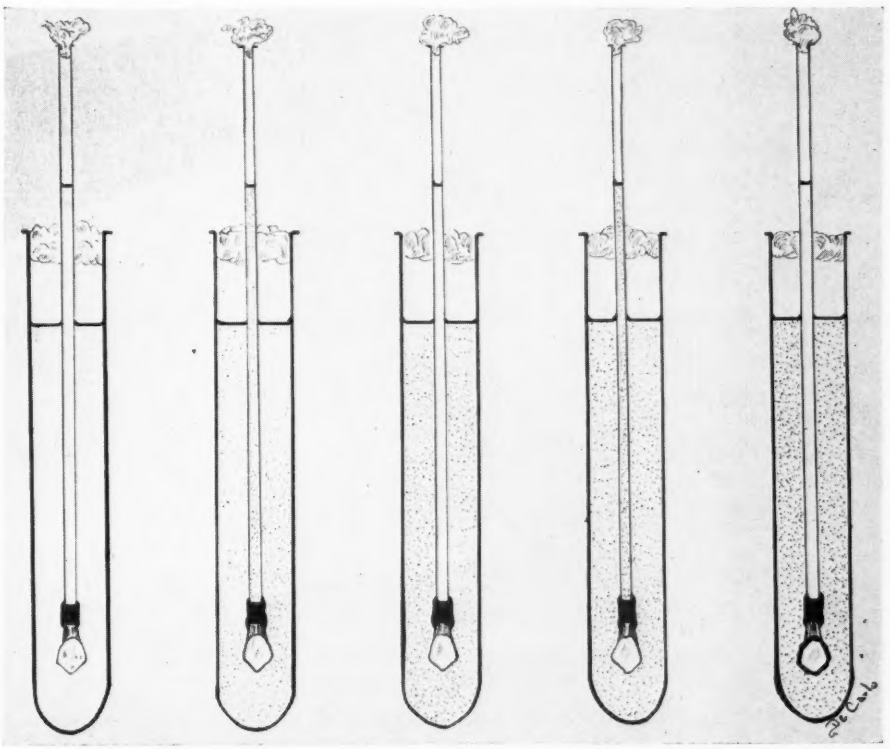

Fig. 2.—A typical experimental series: *Tube 1,* The sterility check; the sterilized assembly after 24 hours' incubation. *Tube 2,* The check for residual antibacterial effect of Roccal solution. Both inner and outer sections were inoculated with test organisms. *Tube 3,* A crown assembly with no perforations in the gold window. The outer section was inoculated with test organisms; the inner section remained sterile. *Tube 4,* A perforated crown assembly. The outer section was inoculated with test organisms; the inner section became contaminated. *Tube 5,* A perforated crown assembly with the gold-acrylic resin margin covered with sealing wax. The outer section was inoculated with test organisms; the inner section remained sterile.

The cast gold veneer crowns were placed in a 1:1,250 Roccal solution (Winthrop Chemical Company) for 45 minutes, and washed in approximately 500 ml. of sterile distilled water divided in three aliquots. This technique proved to be an effective means of sterilizing the acrylic resin veneer crowns.

By careful manipulation, using sterile procedure, the sterilized crowns were attached to the rubber tubing of the inner section, and the inner section was then filled with the same sterile broth as the outer section. All set-ups were checked prior to use for sterility and carry-over of the cold sterilizing agent. The test microorganism used was *Micrococcus pyogenes, var. aureus (N.Y.D.)*.

These organisms were inoculated into the 1 per cent dextrose phenol red brain heart infusion broth of the outer tube, and the entire assembly was incubated for 24 hours. Growth of the microorganism manifests itself in increased turbidity, sediment, and an indicator change from red to yellow.

Dye Penetration Technique.—The assembly noted in Fig. 2 was utilized in this study without sterile precautions. The outer tube contained a dilute solution of alkaline methylene blue, and the inner section contained distilled water. The open end of the glass tubing of the inner section was attached to a filter pump, and vacuum was applied for five minutes.

Fig. 3.—Extension of the dye through the perforations.

RESULTS

The results obtained in a typical experiment in the bacteriologic test group are noted (Fig. 2). Of 10 perforated crowns so tested, one did not show microbial penetration to the inner section. All of the perforated crowns were vulnerable to penetration by the diluted methylene blue solution.

In order to determine the origin of this penetration, the margins or acrylic resin-gold junction was covered with sealing wax. When this was done, contamination of the inner section did not occur (Fig. 2).

Sections of dye-penetrated acrylic resin veneer crowns revealed the path of seepage as occurring at the gold-acrylic resin margin. From there, the dye spread below the acrylic resin facing and through the perforations in the gold window (Fig. 3).

The permeability of the acrylic resin veneer was negligible (Fig. 4). This may be due more to microscopic surface irregularities than actual absorption of the dye.

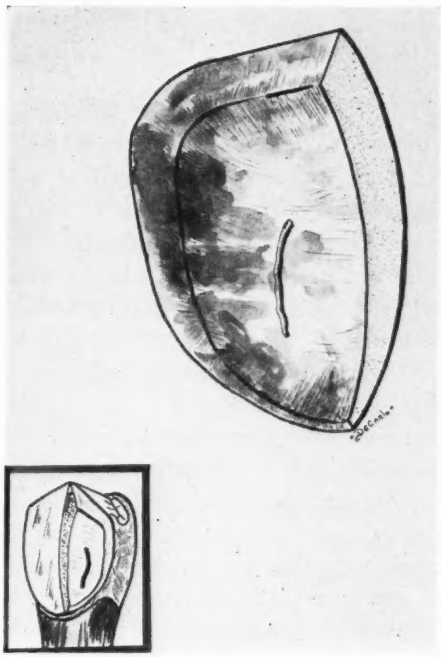

Fig. 4.—Staining of the under surface of the acrylic resin veneer.

CONCLUSIONS

1. The use of cast gold acrylic resin veneer crowns with perforated gold windows is contra-indicated.

2. Evidence was presented to show that crowns so constructed are subject to marginal seepage with extension through the perforations in the gold crowns.

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ADEQUATE OPERATIVE DENTISTRY AND ITS SIGNIFICANCE IN MAINTAINING ORAL HEALTH

E. D. SHOOSHAN, D.D.S.

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WHAT SHOULD BE THE prime objective of our profession? The answer is trite and timeworn—*to maintain oral health and save teeth.*

Today, in dentistry, there are recognized specialties, some of which are justifiable. However, we find some general practitioners and specialists who are becoming "slap-happy" in their various fields and interests.

There are those who are complete-denture-happy and partial-denture-happy. Others are plastic-happy, nutrition-happy, dental-medicine-happy; some are even gold-foil- and rubber-dam-happy. Then there are still others who are mouth-reconstruction-happy, esthetic-happy, endodontics-happy, extraction-happy, and periodontics-*(with minimum scaling)* happy.

All of these various fields and interests are extremely important when properly evaluated and integrated in the care of our patient's dental problems.

I wish to make a plea that more of our profession become *general-practice happy.* In other words, let us become specialists in the practice of general dentistry—happy in the knowledge that by study and improvement in our skills in the various fields of our profession, we will become better-balanced dentists, saving more teeth for more patients for a longer period of time.

The general practitioner of dentistry today, in order to render adequate dental care to his patients, must be versatile in his knowledge and skill, sound in his biologic thinking, and skilled in the arts and techniques of present-day dental practice. He must familiarize himself with new theories and procedures and be able to evaluate and either accept or discard much of the new.

He must keep foremost in his mind the necessity of keeping his patients from the dental crutches of extensive bridgework and partial dentures or from the complete amputations necessary in complete denture prosthesis.

Many patients come to us for dental care, however, who are already dentally crippled, either through their own neglect or through the neglect of their former professional advisors. It taxes the skill of the finest in our profession, to render a service for these patients which will maintain adequate oral physiology, and offset the factors which are causing progressive destruction to the remaining dental members and their foundation structures.

We have the opportunity, however, of seeing many patients, especially in the younger age group, with but minor dental discrepancies; and we are charged

Received for publication Feb. 27, 1956.

with the responsibility of correcting these and maintaining their oral health for the life of the patient—*a large order.*

DIAGNOSIS AND PLANNING

To render a service of this character requires a long-range view in diagnosis and planning. The following may be considered a logical sequence in the examination and diagnosis of the chewing apparatus.

ROENTGENOGRAPHIC EXAMINATION

A complete set of roentgenograms, including the bite-wing type of films, must be a part of our diagnostic records. Their value, however, depends on how well they are made, and how well the dentist studies and relates them to the case. Many times roentgenograms are meaningless unless they are correlated to the clinical findings in the oral cavity.

By means of these roentgenograms, we make note of the condition of the alveolar bone, length of the roots, presence of apical and residual infection, size of the pulp and pulp location, amount of caries present, and presence or absence of serumal deposits.

CLINICAL EXAMINATION

We must make a study of the oral mucosa. This must include the soft tissues immediately adjacent to the teeth and the tissues remote from the teeth.

Clinically we also note malformations of the teeth, missing teeth, the character of previously rendered dental treatment, and a preview of the occlusion.

STUDY CASTS

In most cases, a diagnosis cannot be complete unless very accurate study casts are made and mounted on an adequately adjustable articulator. These casts must be transferred from the patient from a carefully located hinge axis and accurate centric and eccentric registrations.

Study casts mounted in this manner reveal some very interesting data pertinent to our diagnostic procedures. We will find an amazing percentage of patients with an acquired protrusive or convenience occlusion, with the condyles displaced anteriorly from their normal equilibrated positions.

A more accurate functional diagnosis of the chewing apparatus can be made by using the Gnathograph, or writing apparatus. When accurate study casts are mounted upon an articulating instrument that will faithfully reproduce these recorded motions of the mandible, then only is the ultimate in a functional diagnosis possible.

Such a diagnosis reveals the centric position of the mandible and the disharmonies and prematurities of the teeth, not only in this position but also the cuspal interferences in the lateral and protrusive movements and the in-between motions, including the Bennett shift.

It is our observation that these abnormalities prevail in the majority of our patients, and their correction, either by equilibration, by grinding, or by full reconstruction with occlusal restorations, taxes to the utmost the skilled operator.

These complete mouth rehabilitations aimed at restoring normal masticatory function not only improve the physiology of the dentition but restore mismatched and worn teeth to a state of equilibrium in harmony with the hinge axis, centric and eccentric occlusions, and thereby minimize the self-destruction of the teeth which are out of harmony with jaw movements.

This form of treatment requires painstaking effort, time, and thought. Compromises in the treatment of such cases should be labeled as such with an understanding that the final treatment may be disappointing.

PERIODONTAL CARE

It is factually stated that five teeth are lost through the ravages of their investing tissues to one from dental caries. Why should we not spend far more time in the diagnosis of periodontal disease and evaluate the factors which contribute to the loss of these structures? Serumal deposits, malocclusion, nutritional deficiencies, and systemic imbalance can either one or all be important factors in periodontal loss.

It is our responsibility as general dentists either to prescribe and render the treatment for these conditions, or to refer our patients to proper specialists or other practitioners more capable than ourselves of rendering the prescribed care, keeping in mind that *we should oversee their work and demand adequate results from them* just as we would from our auxiliary help.

Although several causative factors have been enumerated in the development of periodontal disease, we should consider with great seriousness that of malocclusion as one of the prime etiologic factors in the disease.

Is it not logical that teeth which are unharmoniously related to their adjacent and opposing members, and which must of necessity take the beating of lateral and torsional stress in the functional movements of the mandible, will be lost from trauma?

The antagonism of the teeth to the chewing movements can but lead to one terminal result—injury to the periodontium and the ultimate loss of the teeth.

PERIODIC TREATMENT

After restoration of the mouth to a condition of health and function, it is our problem to keep it under our control at all times, by careful periodic prophylactic treatment and frequent clinical and roentgenographic examinations.

HOME CARE

Patients must be taught proper daily home care and repeatedly warned to carry out our instructions. We have all seen the discouraging spectacle of well-managed restorative dentistry going bad because of soft tissue and hard tissue disintegration due to the lack of daily routine home care on the part of the patient.

SUMMARY

"Adequate operative dentistry and its significance in maintaining oral health" is the title of this article, and you may wonder why the writer has delved into the phases of dentistry which, at first, do not appear to be pertinent to the subject.

A diagnosis made clinically, roentgenographically, and by accurately mounted study casts is most certainly in the realm of the general practitioner—*the operative dentist.* If he is not to render this service—*who* or what speciality is responsible for this type of service? The answer again is the well-balanced dentist who specializes in the general practice of dentistry.

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COMPLETE DENTURE BASE DEFORMATION WITH VARIED OCCLUSAL TOOTH FORM

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AS THE SCIENCE OF COMPLETE denture prosthodontics progresses, it becomes increasingly evident that careful thought must be given to the design of the teeth used in restorations. Three main schools of thought exist concerning the design of the occlusal surface of the posterior tooth. These are: (1) the anatomic or cusp tooth, an example of which would be the 33 degree posterior tooth; (2) the nonanatomic, or flat plane teeth, an example of which would be the 0 degree posterior or French's posterior teeth; and (3) the moderately cusped tooth—a compromise between the anatomic and nonanatomic tooth forms.

The terms anatomic and nonanatomic are defined as follows: an anatomic tooth is one carved to imitate the unworn natural teeth; the occlusal surface of such teeth have cusps and inclined planes. A nonanatomic tooth is one designed on a mechanical rather than an anatomic basis. Such teeth have no rise in the eccentric excursions due to the occlusal surfaces being virtually flat.

In evaluating the effectiveness of various occlusal tooth forms, two considerations are of primary importance, namely (1) the comminuting efficiency, and (2) the amount of horizontal force transmitted to the residual ridges.

Many tests have been conducted to determine the comminuting efficiency of various designs of occlusal surfaces. Thompson[1] found in a series of tests, that 33 degree anatomic teeth were 65 per cent efficient, 20 degree posterior teeth were 57 per cent efficient, and Hall's inverted cusp teeth were 56 per cent efficient. Payne,[2] when testing anatomic teeth with cusps, and flat, nonanatomic teeth on duplicate denture bases, found that 33 degree anatomic teeth were more efficient in comminuting than flat, nonanatomic teeth. In addition, Schultz, Schuyler, and Trappozano have investigated occlusal tooth force in relation to comminuting efficiency with similar results.[3, 4]

The magnitude of the horizontal component of functional stresses contributed by various occlusal tooth forms in situ has not been investigated. Atrophy or resorption of the residual ridge is of great concern to prosthodontists. Therefore, it is considered imperative to reduce to a minimum the horizontal component of functional forces which cause alveolar ridge changes.

The proponents of nonanatomic teeth claim that the cusp tooth form delivers a maximum horizontal component of functional forces which tends to dislodge the denture and destroy the alveolar ridge. They maintain that these horizontal forces can be eliminated by merely removing the cusps that generate them.

This investigation was supported in part by a Research Grant from the Division of Research Grants and Fellowships of the National Institutes of Health, United States Public Health Service.

Received for publication Dec. 28, 1955.

*Clinical Assistant, Department of Prosthodontics.

In contrast, Schuyler[4] maintains that it is the inclination of the eminentia articularis of the glenoid fossa and the incisal guidance, and not the tooth form, which governs the resultant characteristics of applied horizontal forces. From this we may conclude that variation in the tooth's occlusal form has no influence on the direction of the resultant components of applied forces.

The specific aim of this project is to investigate the influence of varying occlusal tooth forms on the horizontal deformation of complete denture bases. The deformation of the denture base is directly proportional to the horizontal component of force transmitted to the residual ridge. Our investigations included the normal, typical, functional test, and laboratory tests to yield a standard for evaluating the components of in situ functional stress.

MODIFICATION OF TEST DENTURES

The test dentures were modified only to the extent of changing the type of posterior teeth. The sequence of tooth forms used was 33 degree, 20 degree, 0 degree, or French's posterior teeth.

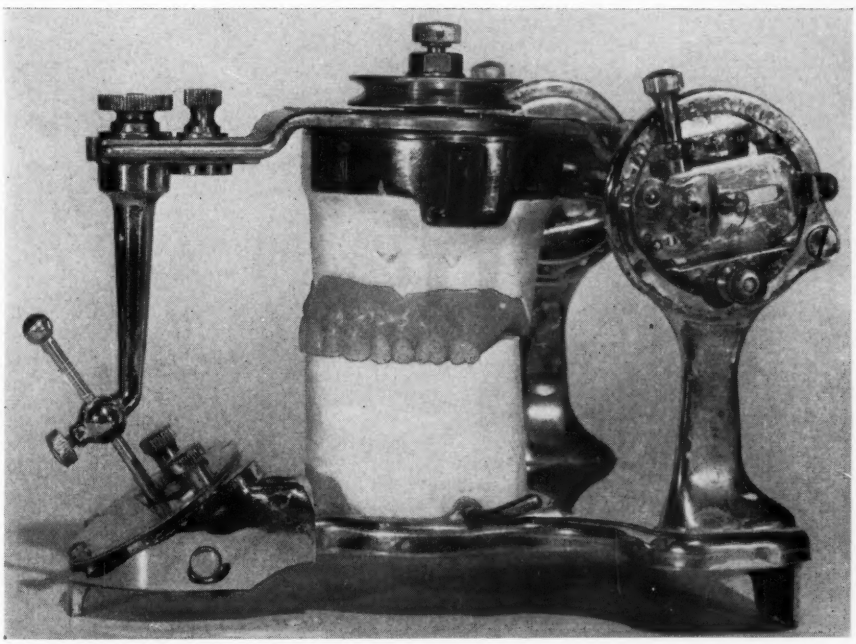

Fig. 1.—The occlusal remounting matrix.

To insure that no positional change was inadvertently incorporated in changing the posterior teeth, a series of matrixes were constructed at the time of completing the machine paste milling and used for this purpose (Fig. 1). The matrix was made to include the occlusal surfaces of the posterior teeth and the buccal flange of the denture, and was keyed into a plaster core which was used to remount the denture (Figs. 2 and 3). Thus each denture could be returned to the articulator independently after testing in exactly the same relationship as had existed at the time of the complete mill-in.

After completing a test series, the denture was repositioned on the articulator, and the posterior teeth were removed and replaced with the next tooth form to be used. The teeth to be repositioned were imbedded in the matrix and reattached to the acrylic resin base by autopolymerizing methyl methacrylate. To

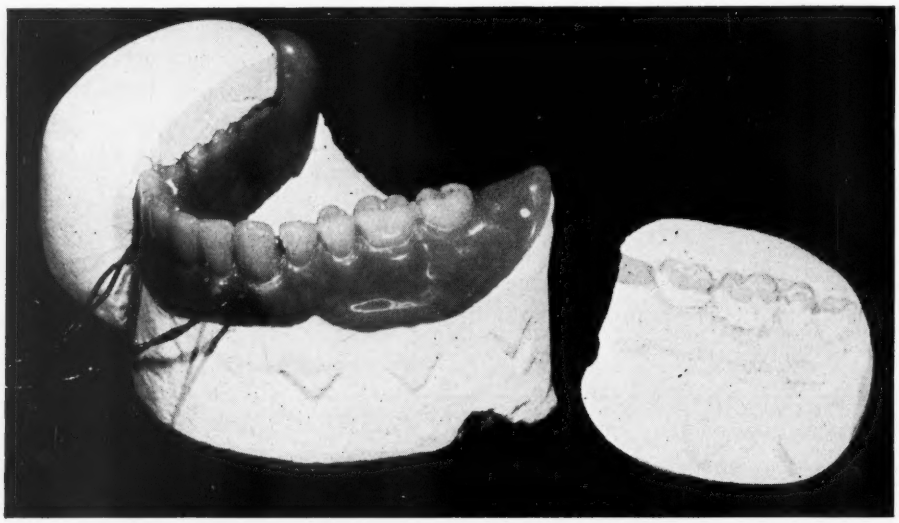

Fig. 2.—The buccal and occlusal cores for remounting the dentures independently.

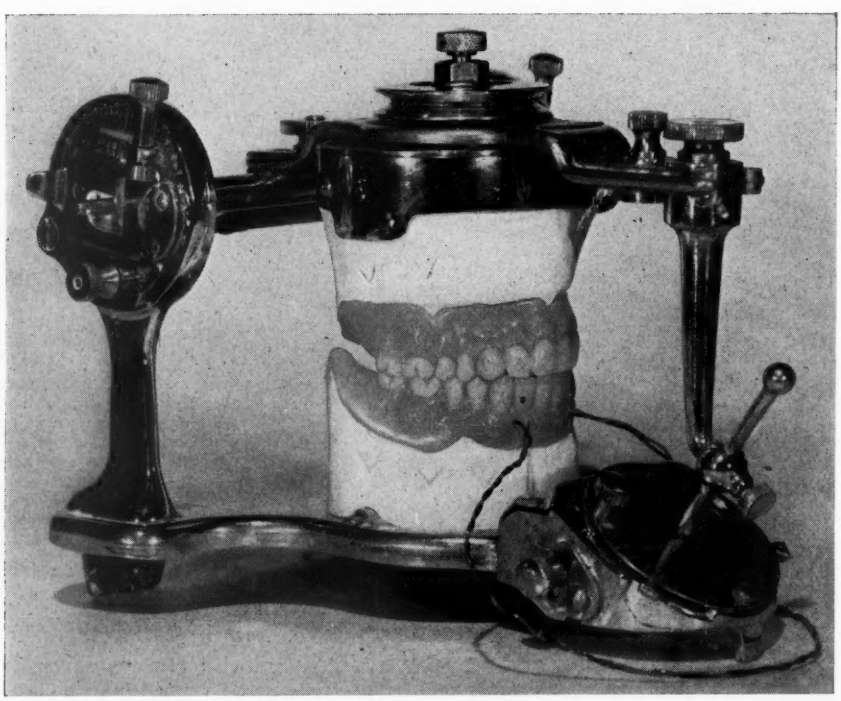

Fig. 3.—The dentures remounted. Note the wire leads from the strain gauges which are attached to the lingual side of the lower denture.

check the validity of our testing procedure, the original 33 degree posterior teeth were remounted on the denture and tested. After remounting the 33 degree posterior teeth, we found the recordings to be the same as those made originally with the 33 degree posterior teeth when using the same test foods.

METHODS AND PROCEDURE

The test dentures were all made of acrylic resin, carrying the selected degree of cusped porcelain posterior teeth. The construction technique included a compound eugenol paste wash impression and the use of a central bearing point, extra oral tracing device, for determining the centric and eccentric movements and for registering the condylar path values. The teeth were set for bilateral balance on a House articulator whose controls were set by plaster interocclusal records.

A sagittal incisal guidance of 10 degrees and a lateral incisal guidance of 20 degrees were utilized in our testing program, so that the 33 degree posterior teeth would not suffer undue cuspal incline reduction. Since the incisal guidance was used in one tooth, it was considered imperative to use it with the various tooth forms tested.

The test subject was a completely edentulous patient who was familiar with the use of artificial dentures. The test foods selected were salted peanuts and raw carrots, which provide a wide range in physical properties. Both types of food were used because Yurkstas and Manly[6] have shown that denture wearers do not yield related performances characterizing masticatory function in either soft or tough food.

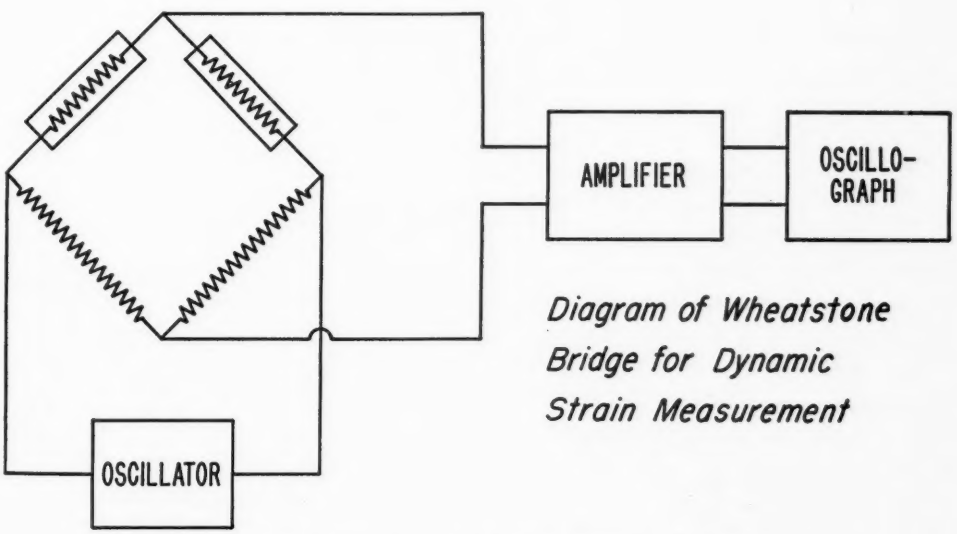

Fig. 4.—Diagram of the Wheatstone bridge for dynamic strain measurement.

ELECTRONIC EQUIPMENT

The electronic measuring equipment used is similar to that used in previous reports[5] and is essentially a Wheatstone bridge (Fig. 4) utilizing a Baldwin Sr-4

strain gauge. These gauges are attached to the lingual side of the lower denture base near the midline, and one gauge was placed directly superior to the other. With this gauge placement, we measured (1) compression—the moving together, or toward the midline, of the denture in a horizontal plane; and (2) extension—a spreading apart, or away from the midline, of the denture in a horizontal plane. Such a placement of the gauges would make possible the detection of torsional rotation within the denture base. However, it is not within the scope of this report to measure the *amount* of torsion; therefore, we will consider it from a qualitative point of view only, as any significant degree of torsion could distort the validity of the horizontal force recordings.

RESULTS

Our tests showed that the 33 degree posterior teeth caused the greatest horizontal deformation of the denture base during mastication. This amounted to 0.51 mm. extension measured from a predetermined point on each distolingual flange of the lower denture. This is 10 per cent greater than that with the 20 degree posterior teeth. The 20 degree posterior teeth caused 40 per cent more denture base deformation than the French's posterior teeth. There was a difference of 50 per cent in denture base deformation between the 33 degree posterior teeth and that of the French's posteriors.

When the patient was asked to "bite down and slide from side to side," without the test foods, the difference in deformation of the base when the three different tooth forms were alternated was negligible and not considered significant (less than 10 per cent). The results are not statistically valid as only one case was used in this study.

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Book Reviews

ATLAS OF CLINICAL PATHOLOGY OF THE ORAL MUCOUS MEMBRANE. Balint J. Orban, M.D., D.D.S., Frank M. Wentz, D.D.S., M.S., Ph.D., and contributors. 135 pages, with 72 colored illustrations, 142 black and white illustrations, and 14 charts. Indexed. St. Louis, 1955, The C. V. Mosby Company. Price $12.50.

An atlas may be defined as a text arranged in outline form. A more recent innovation has been to present brief information in a series of photographs. An atlas is not intended to replace the standard pathology text but in its abbreviated form may be regarded as an auxiliary to it. In this sense, the *Atlas of Clinical Pathology of the Oral Mucous Membrane* is another contribution to the important field of pathology.

The Atlas provides limited coverage of the field of soft tissue lesions of the oral cavity. The arrangement of the material is good. The diagnostic procedures and the classification of lesions are tabulated in a pedantic and useful form. The description of soft tissue diseases includes color reproductions of the gross appearance of the lesions, and photomicrographs in black and white. The black and white illustrations are good, but it is unfortunate that the color reproductions appear to have pink overtones. The clinical features, course of disease, differential diagnosis, etiology, frequency, and therapy are extremely brief, and will require correlation with standard textbooks.

The terminology used is apparently keyed to only one textbook on pathology. It is unfortunate that synonyms were not included which could be found in all texts in this field.

William Lefkowitz

DOCTORS' OFFICES & CLINICS: medical & dental, by Paul Hayden Kirk and Eugene D. Sternberg. Medical Introductions by Dr. John S. De Tar and Dr. Edwin P. Jordan. Architectural Introduction by Frederick Gutheim. First Edition. 209 pages with plans and illustrations. Indexed. New York, 1955, Reinhold Publishing Corporation. $12.00.

The question of whether to build or rent office space is a problem that every physician and dentist must face at some time in his professional career. The purpose of this book is to suggest various plans to those who desire to construct their own offices.

The architects, Paul Hayden Kirk and Eugene D. Sternberg, realizing this problem, have planned offices with necessary efficiency and conveniences that would permit a professional man to attend his patients in a manner fitting to his personality and experience. It seems impossible to depend on rentable area to provide such advantages.

According to the authors, there are three fundamental factors necessary before beginning any construction of this nature. The first is the proper selection of a site, bearing in mind the convenience of patients, the community trends in redevelopment, the possibility of a medical center being built in the community, and nearby locations which would be most desirable for inter-references and consultations. The second consideration is whether the premises are to be occupied singly or shared with other physicians and dentists. The third consideration is the selection of an architect who can assimilate the doctor's ideas in a practical manner, and advise on proper materials for construction of the building to the extent that the maintenance cost would be low and the building would be attractively designed.

Some of the most outstanding clinic buildings in the country are beautifully illustrated, including site plans, photographs of both interiors and exteriors, detailed information as to architecture, owner, type of practice, cost, materials, floor and outside area, heating, air conditioning, and parking facilities.

The reviewer considers this book an excellent reference which architects can make available to their clients in the medical and dental professions. It will serve the physician and the dentist as a guide in the problems of organizing a clinic group, and building a clinic building; it will provide a better understanding of the problems involved in the planning and construction of a building, and point out the advantages and disadvantages of building or renting.

Alexander L. Martone

Special Announcement

NOW AVAILABLE

Reprints of THE GLOSSARY OF PROSTHODONTIC TERMS, bound in heavy paper covers.

THE GLOSSARY OF PROSTHODONTIC TERMS by The Academy of Denture Prosthetics, as edited by The Nomenclature Committee of the Academy: Carl O. Boucher, D.D.S., Chairman; Richard H. Kingery, D.D.S., LeRoy E. Kurth, D.D.S., Victor H. Sears, D.D.S., Vincent R. Trapozzano, D.D.S., and Jack Werner, D.D.S., was published in the JOURNAL OF PROSTHETIC DENTISTRY, Vol. 6, No. 2 (March), 1956. It is the result of three years' effort on the part of the Nomenclature Committee and members of The Academy of Denture Prosthetics. The Glossary consists of 34 pages and contains over 800 terms and definitions. It represents the most modern concepts of the terms used in prosthodontic literature by the majority of the members of the Academy of Denture Prosthetics. It is a useful and valuable reference.

In response to hundreds of requests from individuals, schools, study groups, etc., the Editorial Council of THE JOURNAL OF PROSTHETIC DENTISTRY offers these reprints as follows:

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News and Notes

ANNOUNCEMENTS

The next meeting of the American Denture Society will be held at the Traymore Hotel at Atlantic City, Sept. 28 and 29, 1956. Hotel reservations must be made through the American Dental Association Housing Bureau.

The Centennial Celebration of the St. Louis Dental Society will be climaxed at its 1956 Mid-Continent Dental Congress, Nov. 25 to 28. An outstanding program has been arranged. For further information, write to J. E. Brophy, Executive Secretary, St. Louis Dental Society, 8013 Maryland Ave., St. Louis 5, Mo.

The Greater New York Dental Meeting will be held Dec. 3 to 7, 1956, at the Hotel Statler in New York City.

The next meeting of the American Academy of Crown and Bridge Prosthodontics will be held at the Conrad Hilton Hotel, Chicago, Ill., Feb. 2 and 3, 1957.

The William J. Gies Foundation for the Advancement of Dentistry, Inc., was organized as a permanent tribute to Dr. Gies for his outstanding contributions to the dental profession. Since his recent death we feel more keenly than ever the impact of his inspiration and example, and we are currently completing plans for activating a broad, constructive program. Initially we shall award grants in support of those projects which promote the advancement of dentistry and which were closest to Dr. Gies' heart.

The Foundation invites the University dental schools, other dental institutions, dental groups, individual dentists, and dental periodicals from all sections of the United States to apply for grants to aid projects related to nonproprietary dental journalism, dental literature, dental research, dental education, dental socio-economics, dental public welfare, inter-professional relationships, and dental organizations.

Applications should be accompanied by a complete description of the proposed project, its estimated cost, and a summary of the applicant's pertinent experience. If it is decided that the proposal comes within the program of the Foundation, the applicant will be requested to submit a budget and additional details. All communications should be addressed to: The William J. Gies Foundation for the Advancement of Dentistry, Inc., 120 Wall St., New York 5. N. Y., and received by Oct. 31, 1956.

Dr. Shirl Fox, Clinical Instructor in Prosthetic Dentistry at the College of Physicians and Surgeons, will give up part of his private practice to spend two and one-half days a week at the College starting July 1, 1956. He will assist Dr. Jack Werner, Head of the Prosthetic Department, with the lectures and demonstrations.

The Dental Department of the Beth Israel Hospital announces a postgraduate course on Occlusal Adjustment to be given Sept. 10 to 14, 1956, and a Seminar in Periodontia, Nov. 5 to 16. These courses are under the direction of Henry M. Goldman, D.M.D., and Bernard Chaikin, D.M.D. For further information, write to Director of Public Relations and Education, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

The Ohio State University College of Dentistry announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over two academic years and leads to a Certificate of Graduate Dental Laboratory Technologist. For further information, write to the Chairman of Dental Laboratory Technology, Ohio State University College of Dentistry, Columbus 10, Ohio.

Beginning in October, Northwestern University Dental School will present twenty-one short postgraduate courses spaced at intervals throughout the academic year 1956-1957. The objective of these courses will be to acquaint the general practitioner of dentistry with the newer ideas and techniques of dental treatment. Practically every phase of dentistry will be represented with one or more courses. For further information, write to the Director of Postgraduate Study, Northwestern University Dental School, 311 E. Chicago Ave., Chicago 11, Ill.

The Journal of Prosthetic Dentistry

CONTENTS FOR NOVEMBER, 1956

Through the Eyes of the Editor. Carl O. Boucher, D.D.S., Columbus, Ohio ... 723

Physiologic Denture Technique. Ralph H. Boos, D.D.S., Minneapolis, Minn. ... 726

Physiologic Vertical Dimension and Centric Relation. Thomas E. J. Shanahan, D.D.S., Brooklyn, N. Y. ... 741

Denture Esthetics. H. A. Young, D.D.S., Seattle, Wash. ... 748

Stable Occlusion Rims With Rubber Impression Material. Arthur S. Freese, D.D.S., New York, N. Y. ... 756

The Relationship of Anterior Guidance to Condylar Guidance in Mandibular Movement. Raymond Cohen, D.D.S., New York, N. Y. ... 758

A Study of the Influence of Occlusal Planes on Strains in the Edentulous Maxillae and Mandible. John J. Sharry, D.M.D., Irving J. Weber, D.D.S., and Charles Parkel, Birmingham, Ala. ... 768

A Philosophy of Partial Denture Design. Chester Perry, D.D.S., Detroit, Mich. 775

Lateral Force in Relation to the Denture Base and Clasp Design. Lawrence A. Weinberg, A.B., D.D.S., Brooklyn, N. Y. ... 785

Porcelain Baked to Gold—A New Medium in Prosthodontics. S. Charles Brecker, D.D.S., New York, N. Y. ... 801

The Use and Construction of Gold Crowns With a Fused Porcelain Veneer—A Progress Report. John F. Johnston, D.D.S., R. W. Dykema, D.D.S., and D. M. Cunningham, D.D.S., Indianapolis, Ind. ... 811

A Technique for Temporomandibular Joint Roentgenography. Charles M. Chayes, D.D.S., and Gerald A. Finkelstein, D.D.S., New York, N. Y. ... 822

Report of the Committee on Scientific Investigation. American Academy of Restorative Dentistry. Russell C. Wheeler, D.D.S., Chairman, St. Louis, Mo. 830

The Male Office Manager-Technician in the Dental Office. George E. O'Brien, B.A., D.D.S., and John C. Brutting, Office Manager-Technician, Pleasantville, N. Y. ... 845

Special Announcement

Glossary Reprints ... 852

News and Notes

Announcements ... 853

Directory

Directory ... 855

Index

Index ... 857

(Editorial and Business Communications on page 23)

Vol. 6, No. 6, November, 1956. Journal of Prosthetic Dentistry is published bi-monthly by the C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription rates: United States and Its Possessions $10.00, Students $5.00; Canada, Latin-America, and Spain $10.50, Students $5.50; Other Countries $11.00, Students $6.00. Single copies, $2.50 postpaid. Entered as second-class matter March 13, 1951 at the Post Office at St. Louis, Missouri, under the Act of March 3, 1879. Additional entry authorized at Jefferson City, Missouri. Printed in the U. S. A.

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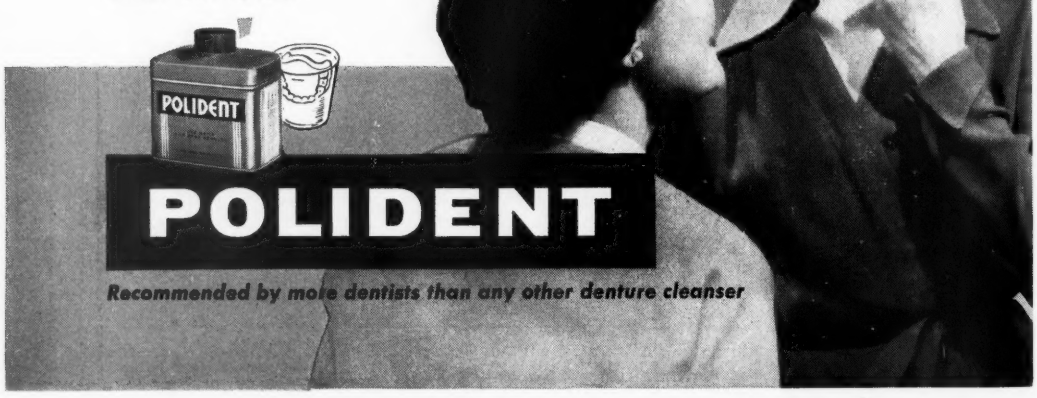

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